Exploring the potential for Amaranth *(Amaranthus spp)* (grain and leaves) in mainstream South African diets

by

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Declaration

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Abstract

Food insecurity and hunger continue to be a global challenge, as many countries remain food insecure and vulnerable to food insecurity. South Africa, despite being classified as food secure, has 26 % of its population experiencing hunger. As a means of addressing food insecurity, there is a renewed focus on indigenous and traditional food crops (ITFCs) and the positive impact on the sustainability of our food and agricultural systems. Amaranth is one of such traditional food crops that has been identified for its exceptional nutritional value and widespread benefits as a sustainable and source of food, which suggests that its promotion into everyday diets can further contribute to households' food supply and improve household food security. A critical question then arises, does amaranth (grain and leaves) have the potential to be mainstreamed in South Africa's food system in order to support sustainable food and nutrition security? Thus, this study has three objectives; (i) to explore the knowledge, awareness, perception and consumption patterns of amaranth (ii) explore the amaranth market and the accessibility to amaranth and its products (ii) to determine the palatability and acceptance of a meal which has been enriched with amaranth. To achieve the first and second objectives, a mixed method non-experimental research approach consisting of individual interviews (n=68) and focus group discussions (n=45) were carried out to explore the knowledge, perception, farming and the consumption of amaranth, which was followed by a desktop research to identify amaranth market stakeholders across the country. One hundred and eight (108) individuals from four (4) communities in Kwazulu Natal; Swayimane, Msinga, Umbumbuly and Nhlazuka participated in the interviews and focus group discussions. For the second objective, a sensory evaluation was carried out to determine the likability of four porridge samples enriched with different amaranth concentrations (100%, 75%, 50% and 25%) and a 100% pure maize porridge sample as the control. Nineteen (19) participants from Swayimane community were recruited as panelists and were required to taste each sample and assess its sensory characteristics using a sensory evaluation questionnaire. Results from the qualitative study show that there is a positive perception about amaranth and existing indigenous knowledge; significant knowledge gaps were identified, such as the lack of knowledge on how to cultivate amaranth, poor knowledge about the utilization/consumption of the grain. The current consumption of amaranth is mostly limited to the leaves only, and the market for it is underdeveloped, although there are several opportunities for improvement. Results from the sensory evaluation show that porridge samples with higher amaranth concentrations (from 50% and above) had higher acceptability scores than 25% amaranth and pure (100%) maize porridge samples. Overall, this study shows that both amaranth leaves and grains can break into the mainstream market as nutritious leafy vegetables and a versatile (pseudo)grain with the right recipes and processing techniques. Provided that they are affordable and promoted with information regarding the origin, sustainability and nutrition, consumers would be willing to cultivate and/or purchase and aid adoption into everyday diets.

Opsomming

Voedselonsekerheid en honger is steeds 'n wêreldwye uitdaging, aangesien baie lande voedselonsekerheid het en kwesbaar bly vir dit. Suid-Afrika, ten spyte daarvan dat dit as voedselkilwer geklassifiseer is, het 26 % van sy bevolking honger ervaar. As 'n manier om voedselonsekerheid aan te spreek, is daar 'n hernude fokus op inheemse en tradisionele voedselgewasse (ITFC's) en die positiewe impak op die volhoubaarheid van ons voedsel- en landboustelsels. Amaranth is een van sulke tradisionele voedselgewasse wat geïdentifiseer is vir sy uitsonderlike voedingswaarde en wydverspreide voordele as 'n volhoubare bron van voedsel, wat daarop dui dat die bevordering daarvan in alledaagse diëte verder kan bydra tot huishoudings se voedselvoorsiening en huishoudelike voedselsekerheid. 'n Kritieke vraag ontstaan dan, het amaranth (graan en blare) die potensiaal om in Suid-Afrika se voedselstelsel hoofstroom te wees ten einde volhoubare voedsel- en voedingsekerheid te ondersteun? Hierdie studie het dus drie doelwitte; (i) om die kennis, bewustheid, persepsie en verbruikspatrone van amaranth (ii) die amaranth mark te ondersoek en die toeganklikheid tot amaranth en sy produkte (ii) om die smaaklikheid en aanvaarding van 'n maaltyd wat met amaranth verryk is, te bepaal. Om die eerste en tweede doelwitte te bereik, 'n gemengde metode nie-eksperimentele navorsingsbenadering bestaande uit individuele onderhoude (n = 68) en fokusgroepbesprekings (n = 45) is uitgevoer om die kennis, persepsie, boerderyendie verbruik van amaranth te verken , wat gevolg is deur 'n lessenaarnavorsing om amaranth markbelanghebbendes regoor die land te identifiseer. Een honderd en agt (108) individue uit vier (4) gemeenskappe in Kwazulu Natal; Swayimane, Msinga, Umbumbuly en Nhlazuka het aan die onderhoude en fokusgroepbesprekings deelgeneem. Vir die tweede doelwit is 'n sensoriese evaluering uitgevoer om die smaak van vier papmonsters te bepaal wat met verskillende amaranth-konsentrasies verryk is (100%, 75%, 50% en 25%) en 'n 100% suiwer mieliepapmonster as die kontrole. Negentien (19) deelnemers van Swayimane gemeenskap is gewerf as paneellede, elke monster was geproe en evalueer asook die sensoriese eienskappe met behulp van 'n sensoriese evaluering vraelys. Resultate van die kwalitatiewe studie toon dat daar 'n positiewe persepsie oor amaranth en bestaande inheemse kennis is; beduidende kennisgapings is geïdentifiseer, soos die gebrek aan kennis oor hoe om amaranth te kweek, swak kennis oor die benutting/verbruik van die graan. Die huidige verbruik van amaranth is meestal slegs beperk tot die blare, en die mark daarvoor is onderontwikkeld, hoewel daar verskeie geleenthede vir verbetering is. Resultate van die sensoriese evaluering toon dat papmonsters met hoër amaranth konsentrasies (van 50% en hoër) het hoër aanvaarbaarheidstellings aswat 25% amaranth en suiwer (100%) mieliepapmonsters. Algehele, hierdie studie toon dat beide amaranth blare en korrels kan breek word in die hoofstroom mark as voedsame blaargroentes en 'n veelsydige (pseudo) graan met die regte resepte en verwerking tegnieke. Met dien verstande dat dit bekostigbaar is en bevorder word met inligting oor die oorsprong, volhoubaarheid en voedingswaarde, sal verbruikers meer bereid wees om dit te kweek en deel maak van alledaagse diëte.

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List of Abbreviations

SA	South Africa
UN	United Nations
SDG	Sustainable Development Goals
FAO	Food and Agriculture Organisation
WHO	World Helath Organisation
DDS	Dietary Diversity Score
ITFC	Indigenous and Traditonal Food Crops
UKZN	University of Kwazulu-Natal
SANHANES	South African National Health and Nutrition Examination Survey
PE	Protein Energy
SFBDG	South African Food Based Dietary Guidelines
NCDs	Non-Communicable Diseases
EAAI	Essential Amino Acid Index
INP	Integrated Nutrition Programme
IMCI	Integrated Management of Childhood Illnesses
CASP	Comprehensive Agricultural Support Programme

Chapter 1

1. Introduction

1.1 Background

Food insecurity and hunger continue to be a global challenge as many countries remain food insecure and vulnerable to food insecurity despite increased production and cheaper food availability (Ericksen *et al.*, 2010). It is estimated that about 821 million individuals, approximately 1 in 9 people in the world are undernourished (FAO, IFAD, UNICEF, WFP, WHO, 2019). However, there are stark differences in the prevalence of food insecurity across different continents. Food insecurity levels are estimated at 7% in Asia, 1.2% in North America and Europe, 6.4% in South America, and Africa with 27.4% has the highest food insecurity levels in the world (FAO, IFAD, UNICEF, WFP, WHO, 2019). In South Africa (SA), according to the 2013 South African National Health and Nutrition Examination Study (SANHANES-1), over half of the population experience some form of food insecurity. Only about 46% of households are food secure, 28 % were at risk of experiencing hunger and 26 % experienced hunger (Shisana *et al.*, 2013). Lacking food security is a constant hazard to which several households in South Africa are exposed. A majority of people at risk of hunger or currently experiencing hunger and food insecurity live in predominantly rural communities with high poverty levels. These include individuals living in provinces like Limpopo, Eastern Cape and KwaZulu-Natal. These populations also suffer higher rates of child hunger (for children aged five years or younger) and other forms of malnutrition, including stunting (undernutrition) and micronutrient deficiencies (Shisana *et al.*, 2013; Statistics South Africa, 2019).

In response to world hunger and food insecurity, the United Nations (UN) Sustainable Development Goal 2 (SDG 2) seeks to achieve zero hunger by 2030, with targets to ensure universal access to adequate, safe and nutritious food, tackling malnutrition, doubling agricultural productivity and incomes of small-scale food producers and maintaining plant genetic diversity (UN, 2019). The SDG 2 target aligns with the pillars of food and nutrition security, which are availability (having enough food), access (sufficient resources to obtain food), utilization (balanced diet, food safety) and stability or sustainability (ensuring the other three pillars remain consistent over time) (Weingärtner, 2004; Hwalla *et al.*, 2016; Fanzo, 2019). Food and nutrition security is achieved when adequate food (quantity, quality, safety, socio-cultural acceptability) is available

and accessible and satisfactorily used and utilized by all individuals at all times to live a healthy and active life (Gross *et al.*, 2000; Weingärtner, 2004).

The Food and Agriculture Organisation (FAO) surmises that strengthened food systems can provide answers for achieving the Sustainable Development Goals' targets of eliminating hunger, food insecurity and malnutrition and increasing resilience to climate change and economic threats (FAO, 2018; Fanzo, 2019). In the same vein, the SA Government, through the New Growth Path policy, recognises that building a resilient food system can help solve food insecurity (Hendriks, 2013). Resilient food systems embody complex relationships between the environmental, economic and social pillars of sustainable development as part of a collaborative network that integrates food production, processing, distribution, consumption and waste management (Fanzo, 2019; IFPRI, 2019). Therefore, food systems at global, regional or national levels should be efficient, healthy, inclusive, resilient and sustainable to ensure food and nutrition security.

Currently, our food system is far from being resilient or sustainable. The Intergovernmental Panel on Climate Change (IPCC) report on climate change estimates that up to 37% of greenhouse gas emissions can be attributed to the global food system's activities (IPCC, 2019), demonstrating that the food system is a chief driver of climate change. On the other hand, the effect of climate change on food security affects people differently depending on their livelihoods and socio-economic status (Islam & Winkel, 2017). Individuals living in predominantly rural and agrarian communities with high poverty levels who are most susceptible to hunger and food insecurity (as the case is in some rural communities in SA) suffer disproportionately more from the adverse effects of climate (Department of Enviromental Affairs, 2016). The impacts of climate change such as prolonged droughts, shifts in planting and harvesting times due to changes in seasonal weather (IPCC, 2019) and increase in the incidence and distribution of pests and diseases can lead to crop and livestock loss and consequently lead to a reduced household food consumption and losses in agricultural income (Alfani *et al.*, 2019). Hence, it is clear that we need to rethink our food ways and transform our food system to make it more resilient and sustainable. Transforming our food systems also means re-examining our food ways and taking into account local resources, including land and water availability, as well as local economies and culture (IFPRI, 2019).

In terms of food and nutrition security, there are two major limiting factors in global agriculture and food systems (FAO, 2018), which have also been observed in South Africa: limited production diversity and a reliance on a few staple crops. Most of the world receives the bulk of its calories from limited food species-notably cereals such as wheat, rice and maize (National Research Council, 1984; Awika, 2011). This dependence on a few crops holds inherent nutritional,

economic, ecological and agro-economic risks that are unsustainable in the long term (Ebert, 2014). From a nutrition angle, an abundant supply of these crops alone, even though they can provide adequate calories, do not provide sufficient nutrition and can lead to unbalanced diets and ultimately malnutrition (Chibarabada *et al.*, 2017). Furthermore, the cultivation of these crops through conventional agricultural practices are a major contributor to climate change. The high input requirements for farming, such as inorganic fertilisers and pesticides, are accelerating natural biodiversity erosion (Otero *et al.*, 2015; Lucas & Horton, 2019), leaving the food system more vulnerable to environmental shocks. This can be more disastrous for South Africa, which currently is water-stressed with limited arable land (10% of the total landmass) (WWF, 2018; World Bank, 2019). This further serves as an urgent call to action to improve the sustainability of food systems.

It is pertinent therefore that we re-examine our food ways to reduce dependence on a few crops, and consider new or alternative approaches to diversify our food system. Such considerations would entail looking beyond conventional crops into lesser-known crops which have a wide-ranging collection of species that can provide nutrient diversity and increase resilience in the production systems (Durst & Bayasgalanbat, 2014). Consequently, this has led to a renewed focus on indigenous and traditional food crops (ITFCs) and the positive impact they have on our production and food systems. Indigenous and traditional food crops (ITFCs) are often referred to interchangeably with *"neglected and underutilised species" (NUS), "wild foods" or "orphan crops".* These crops such as amaranth, fonio, sorghum, teff are as Chivenge *et al.*, (2015) defines them, "crops that have not been previously classified as major crops, are under-researched, currently occupy low levels of utilisation and are mainly confined to smallholder farming areas". In the past, local African communities depended greatly on the large diversity of these traditional food crops for food and as a source of nutrition (Shava, 2000). In modern times, however, these foods have edged out of many diets in favour of conventional or common crops. This change has impacted the economic, socio-cultural and natural environments of many South Africans and has severely eroded the indigenous knowledge base (Hart & Vorster, 2007) chief among which is the cultural significance of these crops.

1.2 Rationale

Studies have shown that indigenous and traditional crops boast superior nutrient density and quality. Moreover, these crops provide greater genetic diversity (Foley, 2005) with over 7000 species known to be used as food worldwide.This is a large contrast to the mere 12 species which currently contribute to 80% of modern day total dietary intake (Bharucha & Pretty, 2010). Furthermore, ITFCs often occupy certain niches in their local ecology and because they are well-adapted to different ecological zones, they often have the potential to "grow themselves" using minimal water and marginal soil conditions (Mabhaudhi *et al.*, 2018). Hence, they are more likely to be a sustainable and nutritious source of food and support the food system. In this regard promoting traditional foods could be a powerful means of achieving the SDG goal 2 of zero hunger. This therefore calls for interventions to stimulate the production of indigenous and traditional food crops and promote their inclusion into everyday diets.

Common ITFCs in SA include legumes (e.g Bambara groundnut, cowpea), tubers (e.g taro, cassava), grains (e.g sorghum, amaranth, and millet) and a host of green leafy vegetables commonly referred to as African leafy vegetables (ALVs) like cleome, pumpkin leaves, spider plant, and Amaranth. However, amaranth belongs to special class because it serves a dual purpose as a green leafy vegetable and a grain (pseudo-grain). The leaves are rich in essential vitamins and minerals (Venskutonis & Kraujalis, 2013) and the grain has a high protein content comparable to levels recommended by FAO and WHO for optimal health (Saubhik, 2016). It is well adapted to the South African climate and has drought resistant properties. The major areas where amaranth is found are KwaZulu-Natal, North West, Mpumalanga and Limpopo provinces (DOA, 2013), some of which are provinces disproportionately affected by high levels of hunger and malnutrition (Shisana *et al.*, 2013). Its superior nutrient content can improve dietary diversity and reduce hunger and malnutrition. Being drought tolerant, the cultivation of the crop will ease the pressure on the ecosystem and promote sustainable food production. Amaranth, therefore, has a crucial part to play in our food and agricultural systems.

1.3 Problem Statement

Despite their many benefits, the use of ITFCs in South Africa have gone unrecognised (Mbhenyane, 2017), and their consumption is found to be on a decline (Rensburg *et al.*, 2007; Thandeka *et al.*, 2011). One of the reasons for this decline is how indigenous knowledge concerning ITFCs are being lost from generation to generation. This poor transfer of indigenous knowledge and the labelling of indigenous leafy vegetables such as Amaranth as "weeds",

creating a negative image of the crop (Voster *et al.*, 2007; Taruvinga and Nengovhela, 2015). This poses a hindrance to the proper development and promotion of the crop, such that cultivation of amaranth is still limited in extent and scale in South Africa. For example, in South Africa, the amaranth production levels are not known (DOA, 2013). Another challenge to the consumption of ITFCs is the changing dietary preferences in the country, also of importance is the perception of these crops and the difference between intention to use and actual practice (Akinola *et al.*, 2020). Traditional foods are being regarded as 'poor man's food' (Demi, 2014). This label has stigmatized ITFC's with the younger demographic (Taruvinga & Nengovhela, 2015) and has caused a shift away from traditional foods staples, towards more conveniently purchased foods (Tull, 2018). Furthermore, ITFCs like amaranth are managed by traditional or local food system (Padulosi *et al.*, 2013) and form part of the informal markets, characterised by low production, poor regulation and inconsistent or seasonal supply. This has caused the development and cultivation of these foods to be severely underplayed, shunned and marginalized by mainstream markets (Bvenura & Afolayan, 2015).

1.4 Research Question and Objectives

Considering the points listed above, the question then arises, how do we propel amaranth from the status of being underused to making it mainstream and included in everyday diets? This question is a complex one, and to achieve this will require an integrated, multidisciplinary and multi-stakeholder intervention, far above the scope of this study. However, a good place to start is to explore the three areas of weakness identified above. Since they point mainly to ITFCs in general, it will be good to understand how they apply to amaranth in particular as they form areas of focus relevant to the creation of interventions regarding the cultivation and utilisation of Amaranth. Hence, we explore the

i. knowledge: existing knowledge, perception, attitudes and practices related to amaranth production and utilization,
ii. market access: how is the market for amaranth? is amaranth and its products accessible to consumers?
iii. dietary preferences: difference between intention to consume and actual practice, how to tailor amaranth to meet the dietary preferences of target consumers.

By examining these, the study seeks to identify the crucial points for intervention and provide further recommendation towards factors that promote consumption of the selected crop. To limit the scope of the study however, we will focus on Kwazulu-Natal province, being one of the

locations with higher rates of hunger and food insecurity in the country and where amaranth grows wildly.

The following question guides the study.

Research question: Does Amaranth (grain and leaves) have the potential to be mainstreamed in South Africa's food system in order to support sustainable food and nutrition security?

Objectives

1. To understand the knowledge, awareness, perception and consumption patterns of Amaranth
2. Explore the markets for amaranth and its products, as well as consumer accessibility to the crop
3. Determine the palatability and consumer acceptance of a meal which have been enriched with amaranth.

1.5 Thesis layout

This chapter sets out the challenge with food and nutrition insecurity in South Africa and the inability of our food system to address this issue. It discusses how the mainstreaming of indigenous foods like amaranth into the food system can improve dietary diversity and make our food systems more resilient. The chapter then provides the rationale for the study and subsequently the objectives of the study.

Chapter 2 is a review of the literature on amaranth, it provides a brief description on its history and the physical characteristics of the crop, its superior nutritive value to meet the dietary needs of South Africans, and distinctive physiological traits for combatting climate change. It also tries to capture the state of amaranth in the country, production, marketing, and consumption of the crop.

Chapter 3 relates to objective 1 and 2 of the study, two approaches were used. First, a quantitative non-experimental research approach consisting of individual interviews and focus group discussion was followed to explore the knowledge, perception farming, and Amaranth consumption in four (4) communities in Kwazulu Natal. Secondly, a survey of shops, retail stores and supermarkets in combination with a desktop research was carried out to identify how and where amaranth is being sold as well as the type of amaranth and amaranth products available in the market. Subsequent results are discussed.

Chapter 4 describes the sensory survey carried out to determine the palatability and acceptability of a meal which have been enriched with amaranth grain (objective 2). The sensory evaluation involved the preparation of five different porridge samples with different ratios of amaranth and maize, after which sensory characteristics of the porridge samples were evaluated by a consumer sensory panel. The panelist were required to taste the samples and record their observations via a sensory evaluation questionnaire. The degree of acceptance of the porridge samples and the willingness to continue consuming it was determined.

Chapter 5 provides the final conclusions and recommendations of the study.

References

Akinola, Racheal, Pereira, Laura Maureen, Mabhaudhi, Tafadzwanashe, de Bruin, Francia-Marié & Rusch, Loubie (2020) 'A Review of Indigenous Food Crops in Africa and the Implications for more Sustainable and Healthy Food Systems', *Sustainability*, 12(8), p. 3493. doi: 10.3390/su12083493.

Alfani, F., Arslan, A., McCarthy, N., Cavatassi, R. & Sitko, N. (2019) 'Climate-change vulnerability in rural Zambia: the impact of an El Niño-induced shock on income and productivity', *FAO Agricultural Development Economics Working Paper*. Rome, 19–02, p. 41. Available at: www.fao.org/publications.

Awika, Joseph M. (2011) 'Major Cereal Grains Production and Use around the World', *ACS Symposium Series; American Chemical Society*. Washington, DC. Available at: https://pubs.acs.org/sharingguidelines.

Bharucha, Zareen & Pretty, Jules (2010) 'The roles and values of wild foods in agricultural systems.', *Philosophical transactions of the Royal Society of London*. The Royal Society, 365(1554), pp. 2913–26. doi: 10.1098/rstb.2010.0123.

Bvenura, Callistus & Afolayan, Anthony J. (2015) 'The role of wild vegetables in household food security in South Africa: A review', *Food Research International*, 76, pp. 1001–1011. doi: 10.1016/j.foodres.2015.06.013.

Chibarabada, Tendai P., Modi, Albert T. & Mabhaudhi, Tafadzwanashe (2017) 'Expounding the value of grain legumes in the semi- and arid tropics', *Sustainability*, 9(60). doi: 10.3390/su9010060.

Chivenge, Pauline, Mabhaudhi, Tafadzwanashe, Modi, Albert T. and & Mafongoya, Paramu (2015) 'The Potential Role of Neglected and Underutilised Crop Species as Future Crops under Water Scarce Conditions in Sub-Saharan Africa.', *International journal of environmental research and public health*. Multidisciplinary Digital Publishing Institute (MDPI), 12(6), pp. 5685–711. doi: 10.3390/ijerph120605685.

Demi, Suleyman Mohammed (2014) 'African indigenous food crops: their roles in combatting chronic diseases in Ghana', *Masters Thesis, Department of Social Justice, Ontario Institute for Studies in Education*. University of Toronto, Ontario, Canada, pp. 1–154. Available at: https://tspace.library.utoronto.ca/bitstream/1807/68528/1/Demi_Suleyman_M_201411_MA_thesis.pdf.

Department of Enviromental Affairs (2016) *Climate Change Adaptation: Perspectives on Urban, Rural and Coastal Human Settlements in South Africa*. Edited by S. Munzhedzi et al. Pretoria, South Africa: Long-Term Adaptation Scenarios Flagship Research Programme.

DOA (2013) 'Most common indigenous food crops of South Africa', *Department of Agriculture Forestry and Fisheries; Directorate of Plant Production*. Directorate Communication Services, p. 6372.

Durst, Patrick & Bayasgalanbat, Nomindelger (2014) 'Promotion of underutilized indigenous food resources for food security and nutrition in Asia and the Pacific', *Food and Agriculture Organisation of the united Nations Regional Office for Asia and the Pacific*. Bangkok, Thailand, pp. 21–212.

Ebert, Andreas W. (2014) 'Potential of underutilized traditional vegetables and legume crops to contribute to food and nutritional security, income and more sustainable production systems', *Sustainability*, 6, pp. 319–335. doi: 10.3390/su6010319.

Ericksen, Polly J., Stewart, B., Barling, D., Loring, P., Anderson, M. & Ingram, J. (2010) 'The Value of a Food System Approach', *Food Security and Global Environmental Change*, (August 2016), pp. 25–45.

Fanzo, Jessica (2019) 'Healthy and Sustainable Diets and Food Systems: the Key to Achieving Sustainable Development Goal 2?', *Food Ethics*, 4(2), pp. 159–174. doi: 10.1007/s41055-019-00052-6.

FAO, IFAD, UNICEF, WFP, WHO (2019) 'The State Food Security and Nutrition in the World 2019: Safeguarding against economic slowdowns and downturns', *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*. Rome: FAO, p. 239. doi: 10.1109/JSTARS.2014.2300145.

FAO (2018) 'Future Smart Food: Rediscovering Hidden Treasures of Neglected and Underutilized Species for Zero Hunger in Asia', *Food and Agriculture Organization of the United Nations*. Edited by X. Li and K. H. M. Siddique. Bangkok, Thailand: FAO, p. 36. doi: 10.18356/23b5f7ab-en.

Foley, Wendy (2005) 'Tradition and change in urban indigenous food practices', *Postcolonial Studies*, 8(1), pp. 25–44. doi: 10.1080/13688790500134356.

Gross, Rainer, Schoeneberger, Hans, Pfeifer, Hans & Preuss., Hans-Joachim A. (2000) 'The Four Dimensions of Food and Nutrition Security:Definitions and Concepts', *Nutrition and Food Security*. Rome: FAO. doi: 10.1007/s12571-019-00941-y.

Hart, T. G. .. & Vorster, H. J. (2007) 'African indigenous knowledge systems in agricultural production. A consultative report', *Department of Science and Technology, National Indigenous Knowledge Systems Office (NIKSO)*. Pretoria, South Africa.

Hendriks, Sheryl (2013) 'South Africa's national development plan and new growth path: Reflections on policy contradictions and implications for food security', *Agrekon*, 52(3), pp. 1–17. doi: 10.1080/03031853.2013.821741.

Hwalla, Nahla, El Labban, Sibelle & Bahn, Rachel A. (2016) 'Nutrition security is an integral component of food security', *Frontiers in Life Science*, 9(3), pp. 167–172. doi: 10.1080/21553769.2016.1209133.

IFPRI (2019) *To tackle climate change we need to rethink our food system | :*, *International Food Policy Research Institute*. Available at: https://www.ifpri.org/blog/tackle-climate-change-we-need-rethink-our-food-system (Accessed: 5 May 2020).

IPCC (2019) 'Climate Change and Land: An IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems', *A Report of the Intergovernmental Panel on Climate Change*. Available at: https://www.ipcc.ch/site/assets/uploads/sites/4/2020/02/SPM_Updated-Jan20.pdf.

Islam, S. Nazrul & Winkel, John (2017) 'Climate Change and Social Inequality', *DESA Working Paper No. 152*. Available at: http://www.ejnetindiaresource.org/ejissues/bali.pdfen-.

Lucas, Tamara & Horton, Richard (2019) 'The 21st-century great food transformation', *The Lancet*, 393, pp. 386–387. doi: 10.1016/S0140-6736(18)33179-9.

Mabhaudhi, Tafadzwanashe, Chibarabada, Tendai, Chimonyo, Vimbayi, Murugani, Vongai, Pereira, Laura, Sobratee, Nafiisa, Govender, Laurencia, Slotow, Rob & Modi, Albert (2018) 'Mainstreaming Underutilized Indigenous and Traditional Crops into Food Systems: A South African Perspective', *Sustainability*, 11(1), p. 172. doi: 10.3390/su11010172.

Mbhenyane, Xikombiso G. (2017) 'Indigenous Foods and Their Contribution to Nutrient Requirements', *South African Journal of Clinical Nutrition*, 30(4), pp. 5–7. doi: 10.17660/ActaHorti.2016.1132.16.

National Research Council (1984) *Amaranth: Modern Prospects for an Ancient crop*. Washington, DC. National Academy Press.

Otero, Gerardo, Pechlaner, Gabriela, Liberman, Giselle & Gürcan, Efe Can (2015) *Food Security and Inequality: Measuring the Risk of Exposure to the Neoliberal Diet*, *Simons Papers in Security and Development*. Available at: www.sfu.ca/internationalstudies. (Accessed: 8 May 2020).

Padulosi, Stefano, Thompson, Judith & Rudebjer, Per (2013) *Fighting poverty, hunger and malnutrition with neglected and underutilized species (NUS): needs, challenges and the way forward*. Rome: Bioversity International. Available at: www.bioversityinternational.org.

Rensburg, Jansen van, Averbeke, W. van, Slabbert, R., Faber, M., Jaarsveld, P. van, Heerden, I. van, Wenhold, F. & Oelofse, A. (2007) 'African leafy vegetables in South Africa', *Water South Africa*, 33(3), pp. 317–326.

Saubhik, Das (2016) 'Amaranthus: A Promising Crop of Future', *Springer Science*. Singapore, p. 208 pp. doi: DOI 10.1007/978-981-10-1469-7.

Shava, Soul (2000) 'The use of indigenous plants as food by a rural community in the Eastern Cape: An Educational Exploration', *Masters Thesis*. Rhodes University.

Shisana, O., Labadarios, D., Rehle, T., Simbayi, L., Zuma, K., Dhansay, A., Reddy, P., Parker, W., Hoosain, E., Naidoo, P., Hongoro, C., Mchiza, Z., Steyn, NP, Dwane, N., Makoae, M., Maluleke, T., Ramlagan, S.,

Zungu, N., Evans, MG, Jacobs, L., Faber, M. & SANHANES-1 Team (2013) 'South African National Health and Nutrition Examination Survey (SANHANES-1)'. Cape Town: HSRC Press. doi: 10.1007/s12160-009-9099-2.

Statistics South Africa (2019) 'Towards measuring food security in South Africa: An examination of hunger and food inadequacy', *Statistics South Africa*. Pretoria, South Africa: Statistics South Africa, p. 34. Available at: www.statssa.gov.za.

Taruvinga, Amon & Nengovhela, Rudzani (2015) 'Consumers`Consumers`Perceptions and Consumption Dynamics of African Leafy Vegetables (ALVs): Evidence from Feni Communal Area, Eastern Cape Province, South Africa'. doi: 10.7763/IPCBEE.

Thandeka, N., Sithole, N. & Thamaga-Chitja, J.M Makanda, I. (2011) 'The role of traditional leafy vegetables in household food security in rural KwaZulu-Natal', *Indilinga – African journal of indigenous knowledge systems*, 10(2), pp. 19–5209.

Tull, Kerina (2018) 'Urban Food Systems and Nutrition', *K4D Helpdesk Report 383*. Brighton, UK: Institute of Development Studies. Available at: https://opendocs.ids.ac.uk/opendocs/handle/20.500.12413/14032 (Accessed: 20 January 2020).

UN (2019) 'Sustainable Development Knowledge Goal 2', *Sustainable Development Knowledge Platform*. United Nations. Available at: https://sustainabledevelopment.un.org/sdg2 (Accessed: 26 April 2020).

Venskutonis, Petras R. & Kraujalis, Paulius (2013) 'Nutritional Components of Amaranth Seeds and Vegetables: A Review on Composition, Properties, and Uses', *Comprehensive Reviews in Food Science and Food Safety*, 12(4), pp. 381–412. doi: 10.1111/1541-4337.12021.

Voster, H. .. Ineke, Willem, Jansen van Rensburg, J.J.B, Van Zijl & Sonja, L. Venter (2007) 'Re-Creating Awareness of Traditional Leafy Vegetables in Communities', *Africa Journal of Food Agriculture Nutrition and Development*, 7(4), pp. 1–3.

Weingärtner, Lioba (2004) 'The Concept of Food and Nutrition Security', *Food and Nutrition Security Assessment Instruments and Intervention Strategies*, (I), pp. 1–28. Available at: http://www.oda-alc.org/documentos/1341934899.pdf.

World Bank (2019) 'Arable land (% of land area) - South Africa | Data'. Available at: https://data.worldbank.org/indicator/AG.LND.ARBL.ZS?locations=ZA (Accessed: 6 May 2020).

WWF (2018) *Agricultural water file: Farming for a drier future*. Available at: https://www.wwf.org.za/water/?25441/Agricultural-water-file-Farming-for-a-drier-future (Accessed: 6 May 2020).

Chapter 2

2. Literature Review

2.1 Overview

Amaranthus *spp* is one among the few traditional crops that has gained significant interest (both nationally and internationally) over the past few years, most importantly for its potential role in promoting food and nutrition security and fostering sustainable agricultural systems (FAO, 1997; Bioversity International, 2013). Nutritionally, the leaves and grains (seeds) boasts of superior qualities of macro and micro-nutrients which offer nutrient dense alternatives to common vegetables and cereal crops (such as spinach, rice and maize) (Rastogi & Shukla, 2013), aiding in the promotion of dietary diversity and food security.

Environmentally, the cultivation of amaranth as well as other ITFCs has been acclaimed for its potential for reducing environmental degradation, promoting greater crop diversity and enhancing resilience in the agricultural cropping systems (Alemayehu *et al.*, 2015; Mabhaudhi *et al.*, 2018). As agriculture is one of the major driving forces accelerating climate change (IPCC, 2019), the discussion on how to practice it in a more sustainable and resilient manner has been a major focus and there is increased consideration for traditional foods in the discourse. According to Shelef *et al.*, (2017), the use of traditional food crops in tandem with local food production can help create more sustainable food production within the pillars of sustainable agriculture.

The importance of traditional foods like amaranth goes far beyond providing sustainable and healthy dietary alternatives.The cultivation and consumption of traditional food crops like amaranth can contribute positively to poverty alleviation, creating sustainable cities and communities as well as climate action (Meybeck *et al.*, 2018) especially for developing countries, and climate change vulnerable regions like sub-Saharan Africa. Consequently, amaranth and many ITFCs are attracting resurgent research interest in human nutrition, agronomy, plant breeding and genomics, and even medicine (National Research Council, 2006; Jaenicke & Höschle-Zeledon, 2008).

This chapter explores the history and morphology of amaranth to understand its origins as well as its physical characteristics. The review will further explore the literature to find evidence to its purported superiority and to what extent it can meet the dietary needs of South Africans thereby promoting food and nutrition security and at the same time improve agricultural sustainability and

positively impact the environment. Finally, in keeping with the theme of mainstreaming amaranth we will review the data on the production, marketing, and utilisation of the crop in South Africa as well as in other parts of the world. Here, the gaps within the South African system will also be identified as well as lessons learnt from other countries' production, marketing and use of the crop.

2.2 History of Amaranth

The name '*Amaranth*' is a derivative of the Greek word Anthos, denoted as "immortal" "non-wilting" or "everlasting" (Mlakar *et al.*, 2009). Its origins are believed to be in Central and South America, with evidence of its cultivation dating back to 6700 BC (Assad *et al.*, 2017).The first recorded use of Amaranthus was among the Aztec and Inca civilizations of Central Mexico around the period 1400 to 1500 AD where it was consumed as a staple food, which the Aztecs called it '*huautli*' and believed it had magical properties that gave them super strength (Caselato-Sousa & Amaya-Farf´an, 2012). The Spanish conquest of the Aztec Empire around the 16th century marked the descent of amaranth's use as a staple of the New World. It is believed that the use of amaranth in pagan rituals and human sacrifice shocked the Spanish conquistadores so much that they prohibited its cultivation and consumption calling it an ungodly pagan hence, amaranth fell into disuse (National Research Council, 1984). Around 1700s it was known as a minor grain plant in central Europe and Russia and by the early 19th century it reached Africa and Asia (Mlakar *et al*., 2009). Amaranth is said to have arrived in South Africa in the 1900s, sadly the history of how and when amaranth reached Africa remains relatively uncertain (Sauer, 1988), but it is found throughout the continent in most countries in South America, the Caribbean, India and China (FAO, 2019).

2.2.1 Classification and Morphology of Amaranth

In botanical terms, the amaranth grain (seeds) like quinoa and buckwheat, is dicotyledonous and therefore not a true cereal (Schoenlechner *et al.*, 2008). But the seeds resemble in function and composition those of the true cereals as such, it is referred to as pseudo-cereal (Alvarez-Jubete *et al.*, 2010).

The taxonomic classification of amaranth is as follows;

Kingdom …….. Plantae
Subkingdom ……..... Tracheobionta
Superdivision …… Spermatophyta
Division …….. Magnoliophyta

Class ……..	Magnoliopsida
Subclass ……..	Caryophyllidae
Order ……	Caryophyllales
Family ……	Amaranthaceae
Genus ……	*Amaranthus*

The genus *amaranthus* mainly comprises of about 400 species (Rastogi & Shukla, 2013) but only a handful are currently cultivated as crops and distributed throughout the world, in South America, Europe, Asia, Africa, and Australia (Suma *et al.*, 2002).The different amaranth species can be divided based on their utilization for human consumption into grain amaranth, vegetable amaranth, and weedy amaranth (Suma *et al*., 2002; Rastogi & Shukla, 2013; Kumar & Arya, 2018). Most common vegetable species worldwide include *Amaranthus blitus*, *Amaranthus tricolor*, *Amaranthus cruentus*, *Amaranthus dubius*, *Amaranthus edulis*, and *Amaranthus hypochondriacus.* Some important grain types include *Amaranthus caudatus*, *Amaranthus hypochodriacus*, *Amaranthus cruentus*, *Amaranthus hybridus*, and *Amaranthus mantegazzianus*. A few other species such as *Amaranthus retroflexus*, *Amaranthus viridis* and *Amaranthus spinosus* are weed types and not safe for livestock consumption as they have been found to cause renal failure in livestock (Plumlee, 2004; Caselato-Sousa & Amaya-Farf´an, 2012). Although some researchers such as Caselato-Sousa & Amaya-Farf´an, (2012) warn that these species are also not safe for human consumption, toxicological reports in humans show no indications of amaranth toxicity in humans human risk from consumption (Stegelmeier *et al.*, 2013). In South Africa amaranth is also known as Pigweed (English), “Hanekom” (Afrikaans), “Thepe” (Sesotho), “Imbuya” (isiZulu), “Vowa” (Tshivenda). Known amaranth species in South Africa include *Amaranthus hybridus*, *Amaranthus thunbergii*, *Amaranthus cruentus*, and Amaranthus *caudatus*. (Taleni *et al.*, 2012; DAFF, 2010).

There is high genetic variability in the morphology of amaranth species (Gerrano *et al.*, 2015). Plant characteristics vary in form, from branched to unbranched, prostrate to erect, dwarf to over 4 m in height, and leaves vary in size and colour, from green to reddish rose to reddish purple (Cai *et al*., 2004; Assad *et al.*, 2017) (see Figure 2.1). Amaranth grains are very small in size and have an average diameter of about 1 mm, ranging from 0.9 to 1.7 mm and weighs about 0.6 - 1.3 mg per seed (30–70 times smaller than a typical wheat grain) (Bressani, 2003; Cai *et al.*, 2004). The seed colour varies among species, from pale ivory to golden or creamy yellow to golden, brown and black (see Figure 2.2).

Figure 2.1: Amaranth leaves of various colours and shades
Source: PlantVillage *https://plantvillage.psu.edu/topics/amaranth/infos*

Figure 2.2: The different colours of amaranth grains (seeds)

2.3 Amaranth's Contribution to Adequate Nutrition

Humans beings are said to require at least 51 known nutrients (Graham *et al.*, 2007) in adequate amounts, for the body to function optimally. According to the South African Constitution: Bill of Rights section 27, everyone has the right to have access to sufficient food and water. In addition, the South African Food Based Dietary Guidelines (SFBDG) encourages South Africans to "enjoy a variety of foods….from minimally processed, traditional and indigenous foods, as the increased use of indigenous crops in the South African diet has been identified as having the potential to contribute to an increased intake of fruits and vegetables" (Vorster *et al.*, 2013) and improve dietary diversity.

In their review of dietary patterns in South Africa, Mchiza *et al.*, (2015) reported that there is an overconsumption of staple foods (maize porridge and bread), dietary fat, and added sugar, especially among individuals in rural and informal settlements. As a result, the diets have a low Protein Energy (PE) ratio, low fibre, mineral and vitamin nutrient balance. Data from the South African National Health and Nutrition Examination Survey (SANHANES-1) show that about 40% of South Africans have a low dietary diversity score (DDS) a majority of which are rural informal dwellers (Shisana *et al.*, 2013). Since DDS is positively correlated with indicators macro and micronutrient adequacy (Steyn *et al.*, 2006), a low DDS therefore, may explain the prevalence of micronutrient deficiencies in the country, putting South Africans at risk of non-communicable diseases (NCDs), a health crisis that has been highlighted in the country (Mchiza *et al.*, 2015).

While no single food can contain all the nutrients required for optimal health, amaranth grains has exceptional nutritional compared to other grains, and is often referred to as a "super food"(Ekesa, 2017). As a pseudocereal, it is gluten free, which means that is is safe to consume by individuals who suffer from celiac disease (Schoenlechner *et al.*, 2008). The grains contain the highest amount of protein as well as more dietary fats and fiber, compared to true cereal such as maize (Venskutonis & Kraujalis, 2013) (See table 2.1).

Table 2.1: Macronutirent comparison of amaranth and maize grains

Component	Amaranth grain	Maize grain
Starch (g/100g)	61.4	71.3
Protein (g/100g)	16.5	8.7
Dietary Fiber (g/100g)	20.6	3.0
Fat (g/100g)	5.7	4.1
Ash (g/100g)	2.8	1.5

Source: (Johnson, 2000; Alvarez-Jubete et al., 2010; Pillay, 2011)

2.3.1 Protein

Amaranth protein composition appears to be generally closer to legumes such as peas, beans and soybeans, except for sulphur-containing amino acids (about 2 to 5 %) being present in higher amounts in amaranth than in legumes (1.4 % on average) (Gorinstein *et al.*, 1991; Venskutonis & Kraujalis, 2013). The protein also has elevated content of the limiting essential amino acid Lysine (Kariuki *et al*., 2013) of about 4.9 to 6.1 g 100 g protein-1 (Mlakar *et al*., 2009) often found in lesser quantities in plants. The high essential amino acid index (EAAI) value (up to 90.4%) showed that amaranth protein is comparable with egg protein (Písaříková *et al.*, 2005). Thus, amaranth protein has a has a balanced amino acid profile which is close to the optimum protein reference pattern in the human diet according to FAO/WHO requirements (WHO, 2007) and the combination of amaranth and maize flour (50:50) nearly reaches the perfect score of 100 on the nutritionist's scale (Mlakar *et al*., 2009).

Another factor that makes amaranth protein so significant is its high digestibility. Protein digestibility estimates of about 80%, 86%, and 89% have been reported by various studies (Kumar & Arya, 2018; Escudero *et al*., 2004; Gamel *et al*., 2004). However, other researchers have found true digestibility values to be lower of only 68.8%–75.4% and 66.1%–76.7% as reported by (Aguilar *et al*., 2015) and (Awasthi *et al*., 2016) respectively. A reason for this could be the presence of antinutritional factors in the crop (D'Amico & Schoenlechner, 2017).

2.3.2 Vitamins

The vitamin profile of amaranth includes ascorbic acid (vitamin C), Beta carotene (a vitamin A precursor) and various B vitamins including thiamin (B_1), pyridoxine vitamin (B_6), riboflavin (B_2) and folate (Venskutonis & Kraujalis, 2013). In the leaves, concentrations of ascorbic acid (vitamin C) varying from 30mg/100g to 117.79 mg/100g (Kachiguma *et al*., 2015), and 112.33 mg/100g (Shukla *et al*., 2006) have been recorded. Also, significant levels of Beta carotene, a vitamin A precursor (25.3 mg/100g) have also being reported (Medoua & Oldewage-Theron, 2014). Processing of amaranth vegetables may influence the contents of its microconstituents: for instance, both sun drying and cooking of significantly reduced Beta carotene and ascorbic acid content (Medoua & Oldewage-Theron, 2014), while oven drying and pressure cooking seem to better retain these nutrients (Yadav & Sehgal, 1995).

Amaranth grain is a good source of riboflavin (0.19 - 0.41 mg/100g), thiamin (0.07–0.10 mg/100g), niacin (3.05–3.72 mg/100g), pyridoxine (0.45–0.61 mg/100g) (D'Amico & Schoenlechner, 2017), vitamin E (5.7 mg/100g) (Bruni *et al.*, 2001; Alvarez-Jubete *et al.*, 2010) and folate 52.8–73.0

µg/100g (Venskutonis & Kraujalis, 2013). Folate is essential for preventing certain birth defects of the brain and spine known as neural tube defects that develop very early in pregnancy (MRC, Vitamin Study Research Group, 1991).

2.3.3 Minerals

Amaranth grains are high in iron and calcium about 5 to 20 times the calcium and iron content compared to other cereal grains (Venskutonis & Kraujalis, 2013). The high calcium content in amaranth leaves and grain may provide up to a 100% of the recommended minimum daily requirement for an adult (1000 to 1300 mg/day), required for bone health and to maintain adequate rates of calcium retention in healthy people (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2015; National Osteoporosis Foundation of South Africa, 2020). This may be of special relevance in relation to the prevention of osteopenia and osteoporosis (Alvarez-Jubete *et al.*, 2010). Table 2.2 shows quantities of major minerals in amaranth grain.

Amaranth leaves are also rich in essential trace minerals (Table 2.3) like copper and zinc (Makobo *et al*., 2010) which help maintain a healthy immune system and are responsible for various metabolic functions in the body (Mayo Clinic, 2017; Copper Alliance, 2018) . Other trace elements in grain amaranth such as molybdenum and chromium have been detected in appreciable concentrations relative to human nutritional needs (Bolaños *et al.*, 2016; D'Amico & Schoenlechner, 2017). Chromium plays a role in insulin action and glucose metabolism (Harvard Health, 2007), while molybdenum serves as a cofactor for at least 4 enzymes (Novotny, 2011).

Table 2.2: Overview of important minerals in Amaranth grains

Minerals	**Unit**	**Alvarez-Jubete *et al*., 2010**	**Kachiguma *et al*., 2015**	**Palombini *et al*. 2013**
Calcium (Ca)	*mg/100g*	180.1± 6.1	370.3 ± 33.07	283.14 ± 5.74
Iron (Fe)	*mg/100g*	9.2 ± 0.2	12.3 ± 0.82	29.35 ± 0.60
Magnesium (Mg)	*mg/100g*	279.2 ± 1.1	65.87 ± 4.574	427 ± 10
Phosphorus (P)	*mg/100g*	n.a	n.a	55.59 ± 1.13
Potassium (K)	*mg/100g*	n.a	341.9 ± 23.06	770.15 ± 15.61
Sodium (Na)	*mg/100g*	n.a	n.a	4.14 ± 0.08
Zinc (Zn)	*mg/100g*	1.6 ± 0.0	0.91 ± 0.097	n.a
Copper (Cu)	*mg/100g*	n.a	n.a	1.25 ± 0.03
Manganese (Mn)	*mg/100g*	n.a	n.a	4.07 ± 0.08
Selenium (Se)	*mg/100g*	n.a	n.a	n.a

Table 2.3: Overview of important minerals in Amaranth leaves

Minerals	Unit	Kachiguma *et al*., 2015	Odhav *et al.*, 2007
Calcium (Ca)	*mg/100g*	2007 ± 48.4	1686
Iron (Fe)	*mg/100g*	19.82 ± 0.555	25
Magnesium (Mg)	*mg/100g*	462.0 ± 15.69	806
Phosphorus (P)	*mg/100g*		487
Potassium (K)	*mg/100g*	1483 ± 35.7	
Sodium (Na)	*mg/100g*		304
Zinc (Zn)	*mg/100g*	1.76 ± 0.062	56
Copper (Cu)	*mg/100g*		3
Manganese (Mn)	*mg/100g*		82

2.3.4 Anti-nutritional factors

The antinutritional compounds found in amaranth include; saponins, tannins, trypsin inhibitors, nitrates, oxalates, phytates, alkaloids and cyanogenic compounds (Schoenlechner *et al.*, 2008) and of particular interest are phytates and oxalates. Phytic Acid or Phytate is considered an antinutrient due to its ability to chelate minerals and trace elements such as zinc, iron, calcium and magnesium, which interferes with their absorption in the gut thus reducing their bioavailability (Valencia-Chamorro, 2003; Beta & Duodu, 2016). Young children are likely to be more sensitive to the effect of phytate since they require more of these minerals for growth, and their digestive systems are more fragile than adults (Rosenberg & Rand, 2009). Therefore, despite being high in iron, the presence of phytate in amaranth could potentially reduce absorption of iron in children (Macharia-Mutie *et al.*, 2012). However, processing by prolonged cooking, popping, and sprouting has been shown to significantly reduce phytate contents of the grain (D'Amico & Schoenlechner, 2017), while blanching and cooking can reduce the phytate content in the leaves (Mwanri *et al.*, 2018).

Oxalates or oxalic acid like phytates have the ability to form chelates with metallic ions such as cadmium, calcium, magnesium, zinc and iron to form poorly soluble compounds that are not readily absorbed from the gastrointestinal tract thus decreasing their bioavailability (Mwanri *et al.*, 2018). Most notably of these compounds is calcium oxalate crystals, these prevent the absorption and utilization of calcium by the body hence increasing the risk for diseases such as rickets and

osteomalacia (Umaru *et al.*, 2016) in children, and cause the formation of kidney stones. This could be a concern especially if calcium intake levels are low to begin with, or if foods high in oxalic acid are consumed on a regular basis over long periods of time (Nyonje, 2015). Pressure cooking amaranth has been reported to reduce oxalate concentrations in amaranth leaves (Ilelaboye *et al*., 2013; Essack et al., 2017; Mwanri *et al.*, 2018).

2.4 Amaranth's Contribution to Environmental Sustainability and Climate Change Action

Climate change is a measurable global reality posing significant social, economic and environmental risks. South Africa like many countries in Africa, is already experiencing the impact of climate change. According to the South African climate change report by the Department of Environmental Affairs, the increase in climate variability in the country is causing changes in rainfall patterns, soil moisture and runoff; evaporation and changing temperatures on aquatic systems (Department of Environmental Affairs, 2017). Since 2015, South Africa has been experiencing drought (with significant crop losses), and more daunting is that climate projections of rainfall and temperature predict the country will get significantly warmer and drier by 2050 (van Wilgen *et al.*, 2016; Jury, 2018).

Amaranth has wide-ranging characteristics that can promote the sustainability of agricultural and food systems and help mitigate the effect of climate change in the country (Durst & Bayasgalanbat, 2014). It is a highly adaptable and resilient crop which responds well to extreme climatic and edaphic conditions such as higher temperatures, higher soil salinity and drought (Omamt *et al.*, 2006; Vorster *et al.*, 2013), and can grow quickly in soils of limited fertility (Saubhik, 2016). This enables amaranth to adapt under diverse geographic and environmental conditions (Assad *et al.*, 2017; Kigel, 2018) from tropical lowlands and mountainous regions of up to 3500 m altitude (D'Amico & Schoenlechner, 2017). Overall, amaranth requires significantly less water for cultivation than most conventional cereal crops, about 53–58% less than that required for wheat and 40–50 % less than maize (Kauffman & Weber, 1990; Alemayehu *et al.*, 2015). Hence, the cultivation of amaranth can promote sustainable use of environmental resources.

2.5 Situating amaranth within the food system

Modern food systems in a case of quantity over quality are often not driven by nutritive value of food but rather by factors such as consistency, predictability, low cost, and high yield (Dwivedi *et al.*, 2017). The same can be said about the South African formal food system, a highly competitive agro-industrial sector, connected with international agribusiness and international finance that

enables access to different, convenient foods at a cheaper price (Termeer *et al.*, 2018). The consequence of which has reinforced de-agrarianisation trends, and influenced consumers to choose the affordable and convenient, but nutritionally poor foods (Pereira, 2014). However, operating at the formal system's margins but structurally disconnected from it are a large number of poorer, small-scale actors that make up the informal food system (Philip, 2010). While the dominant nature of the formal agro-industrial food systems characterised by high production, highly processed foods and large value chains has led to improvements in food supply, it has also resulted in significant trade-offs in terms of environmental degradation, loss of biodiversity, food sovereignty, dietary diversity and socioeconomic stability, especially amongst the rural poor (Mabhaudhi *et al.*, 2018). Hence, the country's ability to deliver on sustainable and healthy food systems under environmental change may well lie with the informal food system characterised by low production, minimally processed traditional food (such as amaranth), and small market sizes.

However, the informal market faces a lot of issues, such as lack of capital, poor infrastructure, including issues around regulation, food safety issues, and personal safety (Tawodzera & Crush, 2019). Perhaps due to being unlicensed, and for the most part unstructured, the informal food system is still being undermined by the formal system and suffers from direct political and economic marginalisation within the South African environment (Siebert, 2020). Policy interventions by the government have proven ineffective in creating the proper structure, enabling environment, and opportunities for innovation, entrepreneurship, and growth (Tawodzera & Crush, 2019). So, it seems that except with the right kind of intervention, the role the informal food sector will play in ensuring sustainable and healthy food systems and mitigating climate change will be ambiguous at best. Without structure and coordination, it will be difficult to obtain reliable data to make informed decisions or projections.

Since this research aims to determine the potential for mainstreaming amaranth, it is important to explore where amaranth fits within the South African food system. Therefore, this section will look at amaranth within the South African food system, focusing on the production, marketing and value chain activities and consumption of the crop to have a clear picture of amaranth within the food system and identify the gaps present. Most importantly, data from South Africa will be compared with that of other countries to determine how well (or not) amaranth is performing compared to those other countries and see what lessons may be learnt.

2.5.1 Amaranth Production and Yields

In South Africa, most of the amaranth consumed is harvested from the wild and not cultivated (Rensburg *et al.*, 2007). Which means that the supply is variable and inconsistent. This inconsistency of supply may be the cause for the declining rate of amaranth consumption (and ITFCs in general) in the country (Rensburg *et al.*, 2007; Thandeka *et al.*, 2011). There is no national data on the production yields of amaranth in South Africa at the national level. In fact, apart from Sorghum, there is no production data on most traditional food crops in South Africa even the common ones like cowpea (no production data from 1999 to date). Since ITFCs are still considered "wild" species they are less considered for large-scale commercial production (Maseko *et al.*, 2017), which goes to prove how undermined and marginalized both traditional foods and the informal food system are. In contrast, Kenya and Tanzania have comprehensive data on production and marketing data for the crop. In 2018 Kenya produced 35,100 tons of vegetable amaranth under production area of 3,264 hectares (Agriculture and Food Authority, 2019) and Tanzania, total vegetable amaranth production was 51,605 tons from an area of 23,573 ha (URT, 2017).

In South Africa, there is very limited published data on production of amaranth and most other ITFCs (Maseko *et al.*, 2017). Most of the data relating to amaranth yields in the country are outcomes from experimental research carried out under controlled environments and not from actual field cultivation, and even these data are primarily for vegetable amaranth only. As such, there is even less data on grain amaranth production and yield in South Africa. This is an example where limited research on a crop could prevent expansion of production to generate new opportunities for increased consumption (Dalton, 2017). However, it is fair to say that the Department of Agriculture, Forestry and Fisheries in South Africa published a production guideline for the plant (DAFF, 2010), perhaps indicating potential interest in amaranth as a crop. Still, there is a significant need for suitable agronomic research to determine yield of amaranth grains as well as other underutilised crops in the country (Maseko *et al.*, 2017).

In their study, Bello *et al.*, (2011) records amaranth leaf yields of 28.55 – 37.57 t/ha in response to different irrigation regimes, and Maboko & Du Plooy, (2012) records amaranth yields 0.83 – 1.31 t/ha, in response to various levels of manure application. However, the Department of Agriculture (DAFF) states that amaranth has the potential to produce fresh leaf yields of up to 40 t/ha (DAFF, 2010) since sustained leaf production is possible, which can be achieved by the removal of flowers. This makes amaranth ideal for promoting food and nutrition security as contiuous production improves access to food.

Production data for amaranth grain from other parts of Africa also show a high variability in yields like Kenya, 50–1500 kg/ha, Nigeria, 400–1500 kg/ha, Uganda 800–2500 kg/ha (Alemayehu *et al.*, 2015) and Tanzania 1204–2920 kg/ha (Mbwambo *et al.*, 2015). Up to 1000 kg/ha yield is considered a good yield (DAFF, 2010). Outside the continent, higher yields of 4600–7200 kg/ha have been recorded in South and Central America, 1200–6700 kg/ha in Europe and 2200-3000 kg/ha in Australia (Gimplinger D.M. *et al.*, 2007). Production values for the countries outside Africa are significantly higher than those within Africa, this may be due to the more mechanised production system, compared to traditional farming systems operated here in Africa.

2.5.2 Markets and Value Chain of Amaranth

It is reported that approximately 52% of South African households still include ITFCs in their diet (the percentage of amaranth is unknown), which points to the key role they play in the food system and ensuring food security in households (Cloete & Idsardi, 2013). Unfortunately, ITFCs like amaranth and other less conventional crops have been the focus of hardly any research on market development activities in the country (van der Merwe *et al.*, 2016). Hence, there is limited data on the marketing of ITFCs, and even more scarce is data specific to amaranth. For example, none of the literature reviewed for this study had specific data for the marketing of amaranth in South Africa. In all the studies reviewed, the researchers often focused on the broad collective category of less conventional indigenous traditional vegetables generally referred to as African leafy vegetables (ALVs) and not findings on individual vegetables. The consequence of this is that it completely neglects grain amaranth and as such data on grain amaranth is almost non-existent. Below, the term ALVs is used to refer to amaranth but also include other vegetables like cleome, blackjack, pumpkin leaves and sweet potato leaves.

In South Africa, ALVs are often produced at a small scale and subsistence level (Cloete & Idsardi, 2013). The small-scale farming sector at this level is characterised by low productivity, lack of access to markets and insufficient market information, as well as poor capacity and a lack of production and marketing infrastructure (DAFF, 2013). Therefore, these crops' marketing is limited to hawking activities and street vending along the roadsides and in open sections of residential areas (Irungu, 2007). The crops are sold at significantly low prices of 5.00 ZAR to R7. 50 ZAR (approx. 0.35 to 7.5 USD) (DAFF, 2010; Senyolo *et al.*, 2017), a trademark of the informal market channels. These vegetables are rarely found in the regular supermarkets and upmarket groceries in South Africa (Maseko *et al.*, 2017) and this is also possibly fueled by the marginalisation of the informal food sector by the formal food markets. Furthermore, this non-presence of ALVs in supermarkets is likely to negatively affect the market development and trade

promotion of ALVs like amaranth in the long term (Irungu, 2007). The value chain of ALVs is simple and undeveloped, and there is no coordination of production and marketing of these vegetables (Maseko *et al.*, 2017). The marketing channel is from small scale farmers to consumers or small-scale farmers to trader (i.e. street vendor/hawker) and then consumer, with no linkages between the farmers and possible processors, wholesalers, or export markets (Senyolo *et al.*, 2017).

Outside South Africa, Kenya has performed better than most countries in Africa. It has achieved a higher saturation of amaranth in its food system, as it is grown on a commercial scale and sold in city markets and is even exported out of the country (NAFIS, 2019). On average the leaves are priced at about 54 Kenyan shillings (approx. 0.5 USD) per kg and the cost of grains per kg falls between 70 Kenyan shillings (0.66 USD) and 120 Kenyan shillings (1.12 USD) depending on the retail outlet (Nzomo *et al.*, 2015). In 2018, vegetable amaranth alone produced in Kenya was valued at 960.7 million Kenyan shillings (8.998 million USD) (Agriculture and Food Authority, 2019). The value chain is more complex and involves a network of actors, including input suppliers, farmers and farmer groups, middlemen, processors, wholesalers, retail traders, and supermarkets (Nzomo *et al.*, 2015; Abel *et al.*, 2019). There is a high participation of both public and private entities which all play a part in the policy, production, promotion and marketing of the crop (NAFIS, 2019). In 2014 Kenya carried out a joint campaign with Benin and Zimbabwe to improve the value chain of amaranth in the respective countries, and the recommendations from the project were geared towards increasing amaranth market access and consumer demand, strengthening seed systems and improving value add for amaranth products and also improvements in governance and policy environment (Chemining'wa *et al.*, 2016). It is no wonder Kenya is perhaps the only exporter of amaranth grain in the continent.

In the international scene, global amaranth market size was estimated at 5.88 billion USD in 2017 and expected to grow at a rate of 11.8 % to reach 14.56 billion USD by 2027 (Reports and Data, 2020). The global amaranth market is segmented into food and beverages, personal care and cosmetics and the pharmaceutical industries and surprisingly and the biggest player in the amaranth market is the personal care and cosmetics sector. North America, Asia Pacific and Europe account for 65% of the global market share (Sharma, 2019) as such, Africa is severely underrepresented. This all goes to show that there is vast potential for South Africa (already a net exporter of other agricultural goods), to tap into the opportunities of amaranth in the international amaranth market. Perhaps, the prospect of foreign exchange may just be the catalyst required to introduce amaranth into the formal food system. This will not only improve foreign exchange at

national level, but also yield profits for the farmer at the local level and help promote poverty alleviation, rural development, and help balance income equality in the country.

2.5.3 Consumption/Utilization of Amaranth

In South Africa, vegetable amaranth (also leaves of grain types) is usually picked fresh and cooked as a relish. The relish can be prepared either by blanching, steaming, boiling, stir frying, and eating together with stiff pap, rice, or homemade bread (Rensburg *et al.*, 2007). A recurring complaint people have about eating amaranth, especially the younger demographic is that it has a bitter taste or after taste (Voster *et al.*, 2007; Hiscock *et al.*, 2018), and there is limited culinary variety in the way it is prepared and consumed (Voster *et al.*, 2007). These may be factors associated with the declining consumption of the crop. Just like in the case of the production and marketing, the study was unable to find data on the preparation and consumption of the grain in the country.

Outside South Africa, vegetable amaranth is also commonly prepared in sauces or soups, and either eaten by itself or with a main dish (Saubhik, 2016). But very young leaves can be eaten raw in salads. In Kenya, the amaranth soup is called "*Ukwaju"* and is made with amaranth leaves and fish fillet while in Nigeria, it is called "*eforiro",* made with an assortment of beef, goat meat, or tripe or all three combined. Grain amaranth on the other hand can be used in a wide variety of dishes. The leaves can be cooked and consumed as a type of porridge or as a condiment on other foods (Myers, 2001), popped by dry heat (without fat addition) (Santra & Schoenlechner, 2016), baked into pies, casseroles and soufflé, or made into pasta (lasagne) (Mlakar *et al.*, 2009).

In Peru, amaranth grain is germinated for sprouts and malted for beer production (traditional beer called '*chicha'*), and in Nigeria, it is fermented and ground into *ogi* (traditional product of lactic fermentation of cereal porridges) and in Asia, it is sometimes used as a substitute for soy in the making of soy sauce ('*shoyu'*) (Mlakar *et al*., 2009). A traditional use of amaranth in Mexico is to mix popped amaranth with a sweet, sticky foodstuff, such as molasses or honey, to make a type of snack bar or crakers (much like a granola bar or Rice Krispy bar) called '*Alegria*' which means happiness in Spanish (see figure 2.3 and 2.4). In India, amaranth is prepared similar to Alegria and called '*Bladdoos',* (Assad *et al.*, 2017) and in Nepal, it is eaten as gruel called *'Bsattoo'* or milled into a flour to make *'chappatis'* (Assad *et al.*, 2017).

Figure 2.3: Plain Alegrias, and Alegrias topped with nuts and dried fruit
Source: http://www.sogoodblog.com/2014/05/04/top-5-ultimate-list-authentic-cinco-de-mayo-mexican-candies/

Figure 2.4 Amaranth alegra type crakcers sold at a Kenyan store
Source https://zucchini.co.ke/products/browns-rosemary-crackers?_pos=1&_sid=faf883427&_ss=r

In Kenya, amaranth grain can be used to make uji, a porridge commonly eaten for breakfast. It is often ground and mixed with ground fish or flour of other cereals such as maize, sorghum and millet to make porridge for children (Wanjala *et al.*, 2016). Figure 2.5 shows a porridge blend sold in Kenyan local supermarket.

Figure 2.5: Flour blends with terere, the local name for amaranth in Kenya
Source (Chemining'wa *et al.*, 2016)

Amaranth is also used for its therapeutic benefits. Amaranth extracts have been used to treat several ailments such as diabetes, diahrrea and even bone fractures in ancient times (Baral & Datta, 2011; Peter & Gandhi, 2017) Although some of these therapeutic benefits are mostly folklore claims, there is evidence of its use in Ayurvedic and Unani system of medicine (Rastogi & Shukla, 2013). Further research is discovering scientific evidence delineating its phytochemical based nutraceutical properties and clinical utility of the plant in various chronic diseases. For example, Aphalo *et al.*,(2015) discovered potential antihypertensive and antioxidant activities of *Amaranthus hypochondriacus* sprouts. Peter & Gandhi,(2017) investigated the pharmacological properties of *Amaranthus spp*. based on in vitro and in vivo studies and found amaranth to have hepatoprotective, anti-malarial, anti-microbial, gastro protective, anti-diabetic, anti-cancerous, antinociceptive, cardioprotective and laxative properties. These properties are due to some of its bioactive substances; rutin, quercitin, isoquercitin, betalains, phenolic acids, hydroxy cinnamates (Khanam & Oba, 2013; Kraujalis *et al.*, 2013).

There is increasing interest in the potential use of amaranth in the cosmetic industry. The unique lipid profile of the oil helps restores skin elasticity, reduces wrinkles and stretch marks, increases hair growth, and is used in cosmetic creams, shampoos, and conditioners (Ronska, 2019). Hence,

extracted amaranth oil (from the seeds) is gaining significance as an essential oil both in aromatherapy and dermatology (Huang *et al.*, 2009).

2.5.4 Fortification of food with Amaranth and consumer acceptability

Food fortification is the addition of one or more essential nutrients not present (or present in small amounts) to a foodstuff product (Doley, 2017). Food fortification is an important practice for reducing micronutrient deficiencies at the population level (Allen *et al.*, 2006). Due to its high nutrient content, amaranth has been used to fortify common cereals like rice and maize and wheat with in order to increase the nutrient density of the fortified mix, particularly protein, iron, calcium and zinc (Tibagonzeka *et al.*, 2014; Kamotho *et al.*, 2017). In their study (MacHaria-Mutie *et al.*, 2013) reported that amaranth enriched porridge containing 70% amaranth and 30% maize, decreased the prevalence of iron deficiency in Kenyan toddlers. Similarly in Ethiopia, amaranth fortified bread containing 70% amaranth and 30% chickpea significantly reduced the incidence of children with anaemia (Orsango *et al.*, 2020). In south Africa, fortification of maize with amaranth leaf powder increased the protein, Lysine and Methionine, and provitamin A contents (Beswa *et al.*, 2016).

Amaranth – maize blends is already being consumed as porridge in places like Kenya (see Figure 2.5). Based on the available nutrient information on amaranth and maize, the macronutrients content of amaranth–maize fortified mix can be estimated at different amaranth concentrations.Table 2.4 provides this breakdown.

Table 2.4: Estimating macronutrient ratios for a different combination of amaranth grain to maize ratios

Macronutrient	100% amaranth	*70:30 ratio	*50:50 ratio	*30:70 ratio	100% maize
Protein	16.5	14.16	12.6	11.04	8.7
Carbohydrate	61.4	64.37	66.35	68.33	71.3
Fat	5.7	5.22	4.9	4.58	4.1
Fibre	20.6	15.32	11.8	8.28	3

*Source: (Johnson, 2000; Alvarez-Jubete et al., 2010; Pillay, 2011). *Estimates have been calculated based on macronutrient content of amaranth and maize*

Based on the above, it can be estimated that substituting 70% of maize with amaranth will provide over 1.5 times the protein, 5 times the fibre, about 20% more healthy fats as well as 10% less carbohydrates compared to the pure maize porridge. A 50:50 amaranth-maize blend will yield 45% more protein, over 3 times fibre and 7% less carbohydrate, while substituting maize with just 30% amaranth will still yield a 27% increase in protein, over 200% increase in fibre, 4% less

carbohydrates and 12% more healthy fats. Figure 4.10 provides a graphical representation of the breakdown.

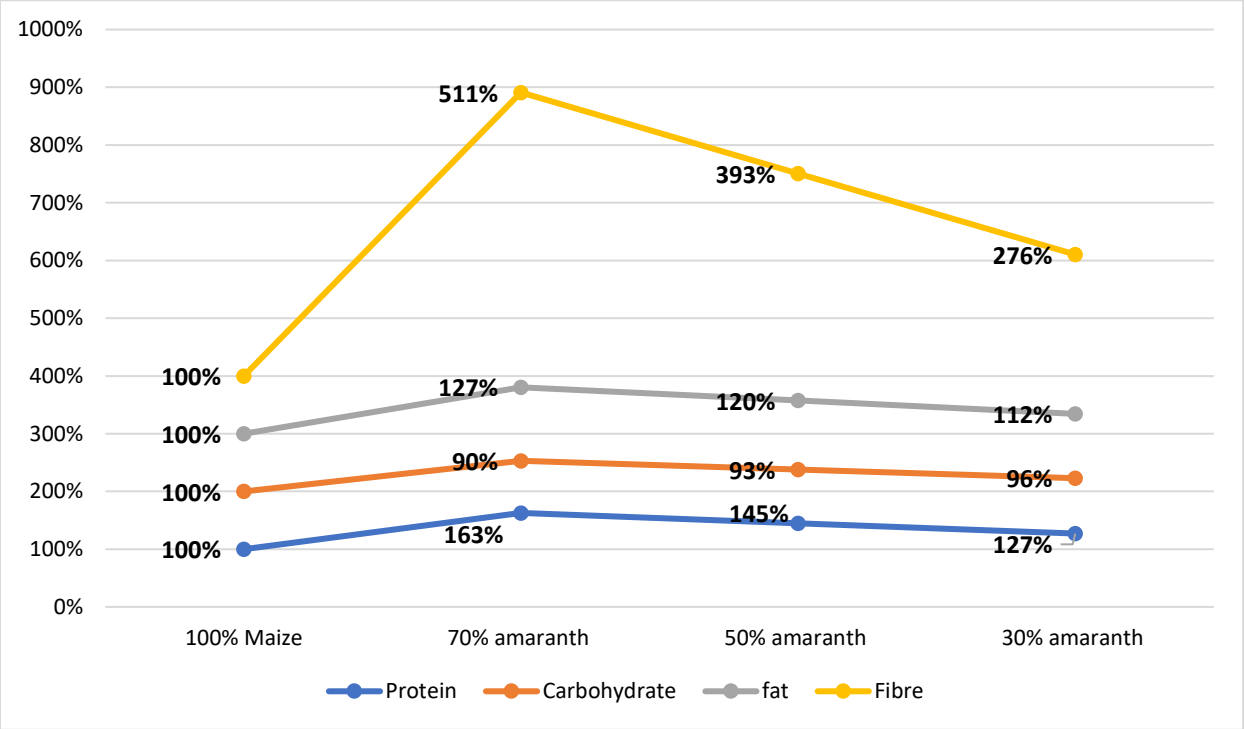

Figure 2.6: a graphical represenatation comparing the macronutrient content of different percentages of amaranth grain with maize

Although fortification of certain foods with amaranth can be crucial for increasing consumption of the crop, the fortified food product may experience changes in physical and sensory properties such as tast, colour or texture, or even overall consistency (Chauhan *et al.*, 2016) and this can be a setback to the acceptability of the food by the consumer. In many cases, the acceptability of the new food product is decreased with the increase in amaranth product as reported by (Capriles *et al.*, 2008), (Beswa *et al.*, 2016) and (Ayo, 2001). This could be because consumers are not familiar with the new fortified product.Thus, to fully achieve consumer acceptability, the fortified food product must also be socially and culturally acceptable to achieve its intended objective on the target consumers (Macharia-Mutie *et al.*, 2011).

2.6 Conclusion

Amaranth is indeed a special plant due to its unique properties and versatile usage, amaranth has gained increased attention around the world since the 1970s. As a superfood, it boasts of superior micro and macro nutrients that can contribute to adequate nutrition in most of South Africans' diets. And although it contains antinutritional factors, these may be easily mitigated with the right processing technique. However, it is likely that the beneficial properties - its nutritional density far outweighs any unlikely harm that may result from consumption of the plant.

The crop has some superior advantages and noted ability to grow successfully in adverse environmental conditions such as high temperature and drought. Additionally, Its ability to grow widespread and quickly to outgrow weeds, and resistance to certain conventional pests and diseases making it suitable for growing in the South African environment, especially with looming climate change impact.

In South Africa, production of amaranth is minimal, and the value chain is underdeveloped, and relegated to the informal sector. However, due to increasing global demand for amaranth products especially within cosmetic industry, it presents a entryway for amaranth to break into the formal market, particularly considering opportunities for foreign trade.

In terms of food, different cultures in Africa, Asia, South America utilise the grains and leaves in unique cuisines, from soups, relish, to snacks and pastries. In South Africa however, there is little evidence for the use of grains and a common complaint is the lack of variety in the leafy vegetable dishes, which tend to be bland. This could be a setback for the consumption of crop but at the same time presents an opportunity for development of new recipes that is more compatible with consumer palate.

References

.Abel, Otieno Benard, Gor, Cristopher Obel, Okuro, Samwel Ongwen, Omanga, Paul Abuto & Bokelmann, Wolfgang (2019) 'The African Indigenous Vegetables Value Chain Governance in Kenya', *Studies in Agricultural Economics*, 121(1), pp. 41–52. doi: 10.7896/j.1818.

Agriculture and Food Authority (2019) 'Horticulture Validated Report 2017-2018', *AMinistry of griculture, Fisheries and Food Authority (AFFA) Horticulture Performance Report*. Nairobi, Kenya: Ministry of Agriculture, Fisheries and Food Authority (AFFA), pp. 1–64. Available at: http://www.agricultureauthority.go.ke/wp-content/uploads/2016/05/Horticulture-Validated-Report-2014-Final-copy.pdf.

Aguilar, Elba Graciela, Albarracín, Graciela de Jesús, Uñates, María Angelina, Piola, Hugo Daniel, Camiña, José Manuel & Escudero, Nora Lilian (2015) 'Evaluation of the Nutritional Quality of the Grain Protein of New Amaranths Varieties', *Plant Foods for Human Nutrition*. Springer US, 70(1), pp. 21–26. doi: 10.1007/s11130-014-0456-3.

Alemayehu, F. Reta, Bendevis, M. A. & Jacobsen, S. E. (2015) 'The Potential for Utilizing the Seed Crop Amaranth (Amaranthus spp.) in East Africa as an Alternative Crop to Support Food Security and Climate Change Mitigation', *Journal of Agronomy and Crop Science*, 201(5), pp. 321–329. doi: 10.1111/jac.12108.

Allen, Lindsay, De Benoist, Bruno, Dary, Omar & Hurrell, Richard (eds) (2006) *Guidelines on food fortification with micronutrients Food and Agricultural Organization of the United Nations Guidelines on food fortification with micronutrients*. Geneva, Switzerland: World Health Organization and Food and Agriculture Organization.

Alvarez-Jubete, L., Arendt, E. K. & Gallagher, E. (2010) 'Nutritive value of pseudocereals and their increasing use as functional gluten-free ingredients', *Trends Food Science and Technology*, 21, pp. 106–113. doi: 10.1016/j.tifs.2009.10.014.

Aphalo, Paula, Martínez, E. Nora, Añón, María Cristina, Aphalo, Paula, Martínez, E. Nora, Cristina, María & Amaranth, Añón (2015) 'Amaranth Sprouts : A Potential Health Promoting and Nutritive Natural Food Amaranth Sprouts : A Potential Health Promoting and Nutritive Natural Food', *International Journal of Food Properties*. Taylor & Francis, 18(00), pp. 2688–2698. doi: 10.1080/10942912.2015.1004585.

Assad, Rezwana, Reshi, Zafar A., Jan, Snober & Rashid, Irfan (2017) 'Biology of Amaranths', *The Botanical Review*. Springer US, 83(4), pp. 382–436. doi: 10.1007/s12229-017-9194-1.

Awasthi, CP, Ajay, Kumar, Nageswer, Singh & Rishi, Thakur (2016) 'Biochemical Composition of Grain Amaranth Genotypes of Himachal Pradesh', *Indian Journal of Agricultural Biochemistry*. Indian Society of Agricultural Biochemists, 29(2), pp. 189–194. Available at: http://www.indianjournals.com/ijor.aspx?target=ijor:ijab&volume=24&issue=2&article=012.

Ayo, Jerome Adekunle (2001) 'The effect of amaranth grain flour on the quality of bread', *International Journal of Food Properties*, 4(2), pp. 341–351. doi: 10.1081/JFP-100105198.

Baral, Manik & Datta, Ankur (2011) *Pharmacognostic studies on stem and leaves of Amaranthus spinosus Linn An approach towards TIITS mediated Immunomodulation of Haematopoietic Stem Cells in Glioma bearing rats.* View project An insight into the Immunotherapeutic effect of T11TS, a novel glycoprotein molecule in Cryptococcus neoformans infections in rats. View project. Available at: www.ijabpt.com

Bello, Zaid, Walker, Sue, Bello, Z. A., Walker, S & Tfwala, C. M. (2011) 'Influence of water supply and harvesting frequency on production of leafy amaranth in a semi-arid region of South Africa Tree transpiration View project AgMIIP View project Influence of water supply and harvesting frequency on production of leafy amaranth', *African Crop Science Conference Proceedings*, 10, pp. 377–381. Available at: https://www.researchgate.net/publication/313443809 (Accessed: 1 June 2020).

Beswa, Daniso, Dlamini, Nomusa Rhoda, Siwela, Muthulisi, Amonsou, Eric Oscar & Kolanisi, Unathi (2016) 'Effect of amaranth addition on the nutritional composition and consumer acceptability of extruded provitamin A-biofortified maize snacks', *Food Science and Technology*. Sociedade Brasileira de Ciencia e

Tecnologia de Alimentos, SBCTA, 36(1), pp. 30–39. doi: 10.1590/1678-457X.6813.

Beta, T. & Duodu, K. G. (2016) 'Bioactives: Antioxidants', *Reference Module in Food Science*. Elsevier. doi: 10.1016/B978-0-08-100596-5.00110-4.

Bioversity International (2013) 'Diversifying Food and Diets: using indigenous vegetables to improve profitability, nutrition and health in Africa', *Routhledge*. Edited by J. Fanzo et al. Oxfordshire, UK.

Bolaños, Daniela, Marchevsky, Eduardo J. & Camiña, José M. (2016) 'Elemental analysis of Amaranth, Chia, Sesame, Linen, and Quinoa seeds by ICP-OES: Assessment of classification by chemometrics', *Food Analytical Methods*. Springer Science and Business Media, LLC, 9(2), pp. 477–484. doi: 10.1007/s12161-015-0217-4.

Bressani, R. (2003) 'Amaranth', in Caballero, B., Finglas, P., and Toldra, F. (eds) *Encyclopedia of Food Sciences and Nutrition (Second Edition)*. 2nd Editio. Elsevier. doi: 10.1016/B0-12-227055-X/01402-4.

Bruni, Renato., Medici, A., Guerrini, Alessandra., Scalia, S., Poli, F., Muzzoli, M. & Sacchetti, Gianni (2001) 'Wild Amaranthus caudatus seed oil, a nutraceutical resource from ecuadorian flora', *Journal of Agricultural and Food Chemistry*. J Agric Food Chem, 49(11), pp. 5455–5460. doi: 10.1021/jf010385k.

Cai, Y. Z., Corke, H. & Wu, H. X. (2004) 'Amaranth', *Encyclopedia of Grain Science*. Elsevier, pp. 1–10. doi: 10.1016/B0-12-765490-9/00001-X.

Capriles, Vanessa Dias, Almeida, Eveline Lopes, Ferreira, Reinaldo Eduardo, Arêas, José Alfredo Gomes, Steel, Caroline Joy & Yoon, Kil Chang (2008) 'Physical and sensory properties of regular and reduced-fat pound cakes with added amaranth flour', *Cereal Chemistry*, 85(5), pp. 614–618. doi: 10.1094/CCHEM-85-5-0614.

Caselato-Sousa, Val´eria Maria & Amaya-Farf´an, Jaime (2012) 'State of Knowledge on Amaranth Grain: A Comprehensive Review', *Journal of Food Science*, 77(4), pp. 93–104. doi: 10.1111/j.1750-3841.2012.02645.x.

Chauhan, Arti, Saxena, D. C. & Singh, Sukhcharn (2016) 'Cogent Food & Agriculture Physical, textural, and sensory characteristics of wheat and amaranth flour blend cookies under a Creative Commons Attribution (CC-BY) 4.0 license Physical, textural, and sensory characteristics of wheat and amaranth flour blend cookies'. doi: 10.1080/23311932.2015.1125773.

Chemining'wa, George, Rudebjer, Per & Hall, Richard (2016) 'Upgrading Grain Amaranth Value Chains in Africa', *Bioversity International*. Kenya, (September), pp. 2014–2016. doi: 10.13140/RG.2.2.27503.43688.

Cloete, P. C. & Idsardi, E. F. (2013) 'Consumption of indigenous and traditional food crops: Perceptions and realities from South Africa', *Agroecology and Sustainable Food Systems*, 37(8), pp. 902–914. doi: 10.1080/21683565.2013.805179.

Copper Alliance (2018) 'Copper Essential for Human Health'. Available at: https://copperalliance.org.uk/knowledge-base/education/education-resources/copper-essential-human-health/ (Accessed: 30 May 2020).

D'Amico, Stefano & Schoenlechner, Regine (2017) 'Amaranth: Its Unique Nutritional and Health-Promoting Attributes', *Gluten-Free Ancient Grains: Cereals, Pseudocereals, and Legumes: Sustainable, Nutritious, and Health-Promoting Foods for the 21st Century*. Elsevier Ltd, pp. 161–178. doi: 10.1016/B978-0-08-100866-9/00006-6.

DAFF (2010) 'Amaranthus: production guideline'. Department of Agriculture, Forestry and Fisheries. Available at: https://www.nda.agric.za/docs/Brochures/Amaranthus.pdf.

DAFF (2013) 'National Policy on Food and Nutrition Policy'. Pretoria, South Africa: Department of Agriculture, Forestry and Fisheries, pp. 1–21. Available at: https://www.nda.agric.za/docs/media/national policyon food and nutririon security.pdf.

Dalton, Timothy J. (2017) 'Global Supply of Ancient Grains in the 21st Century: Keys to Unlocking Their Full Potential', *Gluten-Free Ancient Grains: Cereals, Pseudocereals, and Legumes: Sustainable, Nutritious,*

and Health-Promoting Foods for the 21st Century. Elsevier Ltd, pp. 13–20. doi: 10.1016/B978-0-08-100866-9.00002-9.

Department of Environmental Affairs (2017) 'South Africa's 2nd Annual Climate Change Report'. Pretoria: Department of Environmental Affairs Republic of South Africa. Available at: https://www.environment.gov.za/sites/default/files/reports/southafrica_secondnational_climatechnage_report2017.pdf.

Doley, Jennifer (2017) 'Vitamins and Minerals in Older Adults: Causes, Diagnosis, and Treatment of Deficiency', in *Nutrition and Functional Foods for Healthy Aging*. Elsevier Inc., pp. 125–137. doi: 10.1016/B978-0-12-805376-8.00014-9.

Durst, Patrick & Bayasgalanbat, Nomindelger (2014) 'Promotion of underutilized indigenous food resources for food security and nutrition in Asia and the Pacific', *Food and Agriculture Organisation of the united Nations Regional Office for Asia and the Pacific*. Bangkok, Thailand, pp. 21–212.

Dwivedi, Sangam L., Lammerts van Bueren, Edith T., Ceccarelli, Salvatore, Grando, Stefania, Upadhyaya, Hari D. & Ortiz, Rodomiro (2017) 'Diversifying Food Systems in the Pursuit of Sustainable Food Production and Healthy Diets', *Trends in Plant Science*. Elsevier Ltd, 22(10), pp. 842–856. doi: 10.1016/j.tplants.2017.06.011.

Ekesa, Beatrice Nakhauka (2017) 'Selected Superfoods and Their Derived Superdiets', *Superfood and Functional Food - The Development of Superfoods and Their Roles as Medicine*. InTechOpen, (February), pp. 95–114. doi: 10.5772/67239.

Escudero, N. L., de Arellano, M. L., Luco, J. M., Giménez, M. S. & Mucciarelli, S. I. (2004) 'Comparison of the chemical composition and nutritional value of Amaranthus cruentus flour and its protein concentrate.', *Plant foods for human nutrition (Dordrecht, Netherlands)*, 59(1), pp. 15–21. Available at: http://www.ncbi.nlm.nih.gov/pubmed/15675147.

FAO (1997) 'Agriculture food and nutrition for Africa - A resource book for teachers of agriculture', *FAO Publishing Management Group*. Rome, Italy. Available at: http://www.fao.org/3/w0078e/w0078e06.htm.

FAO (2019) 'Amaranth', *Food and Agriculture Organization of the United Nations*. Available at: http://www.fao.org/traditional-crops/amaranth/en/.

Gamel, Tamer H., Linssen, Jozef P., Alink, Gerrit M., Mosallem, Ahmed S. & Shekib, Lila A. (2004) 'Nutritional study of raw and popped seed proteins ofAmaranthus caudatus L andAmaranthuscruentus L', *Journal of the Science of Food and Agriculture*. John Wiley & Sons, Ltd, 84(10), pp. 1153–1158. doi: 10.1002/jsfa.1781.

Gerrano, Abe S., van Rensburg, Willem S. Jansen & Adebola, Patrick O. (2015) 'Genetic diversity of Amaranthus species in South Africa', *South African Journal of Plant and Soil*, 32(1), pp. 39–46. doi: 10.1080/02571862.2014.973069.

Gimplinger D.M., G. Dobos, R. Schönlechner & H.-P. Kaul (2007) 'Yield and quality of grain amaranth (Amaranthus sp.) in Eastern Austria', *Plant Soil Environ*, 53, pp. 105–112. Available at: https://www.agriculturejournals.cz/publicFiles/00059.pdf.

Gorinstein, Shela, Moshe, Ruth, Greene, Luis J. & Arruda, Paulo (1991) 'Evaluation of four Amaranthus Species Through Protein Electrophoretic Patterns and their Amino Acid Composition', *Journal of Agricultural and Food Chemistry*. American Chemical Society, 39(5), pp. 851–854. doi: 10.1021/jf00005a006.

Graebner, I. T., Siqueira, E. M. A., Arruda, S. F. & Souza, E. M. T. (2004) 'Carotenoids from native Brazalian dark green vagetables and bioavailable: A study in rats', *Nutr Res.*, 24, pp. 671–679.

Graham, Robin D., Welch, Ross M., Saunders, David A., Ortiz-Monasterio, Ivan, Bouis, Howarth E., Bonierbale, Merideth, de Haan, Stef, Burgos, Gabriella, Thiele, Graham, Liria, Reyna, Meisner, Craig A., Beebe, Steve E., Potts, Michael J., Kadian, Mohinder, Hobbs, Peter R., Gupta, Raj K. & Twomlow, Steve (2007) 'Nutritious Subsistence Food Systems', *Advances in Agronomy*, 92(04), pp. 1–74. doi:

10.1016/S0065-2113(04)92001-9.

Harvard Health (2007) 'Chromium: The forgotten mineral', *Harvard Men's Health Watch*. Available at: https://www.health.harvard.edu/newsletter_article/chromium-the-forgotten-mineral (Accessed: 30 May 2020).

Hiscock, Lucil, Bothma, Carina, Hugo, Arnold, Van Biljon, Angeline & Van Rensburg, Willem Sternberg Jansen (2018) 'Overall liking and sensory profiling of boiled Amaranthus leaves using the check-all-that-apply question', *CYTA - Journal of Food*, 16(1), pp. 822–830. doi: 10.1080/19476337.2018.1464521.

Huang, Zih-Rou, Lin, Yin-Ku & Fang, Jia-You (2009) 'Biological and Pharmacological Activities of Squalene and Related Compounds: Potential Uses in Cosmetic Dermatology', *Molecules*. Molecular Diversity Preservation International, 14(1), pp. 540–554. doi: 10.3390/molecules14010540.

Ineke, Voster, Willem, Jansen van Rensburg, B, Van Zijl J. J. & Venter, Sonja L. (2007) 'The Importance of Traditional Leafy Vegetables in South Africa', *Africa Journal of Food Agriculture Nutrition and Development*, 7(4), pp. 1–13.

IPCC (2019) 'Climate Change and Land: An IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems', *A Report of the Intergovernmental Panel on Climate Change*. Available at: https://www.ipcc.ch/site/assets/uploads/sites/4/2020/02/SPM_Updated-Jan20.pdf.

Irungu, Charity (2007) 'Analysis of Markets for African Leafy Vegetables within Nairobi and its Environs and Implications for On-Farm Conservation of Biodiversity', *Global Facilitation Unit for Underutilized Species*. Rome, Italy, pp. 1–45.

Jaenicke, H. & Höschle-Zeledon, I. (2008) 'Strategic Framework for Underutilized Plant Species Research and Development: with special reference to Asia and the Pacific, and to Sub-Saharan Africa', *International Centre for Underutilised Crops, Colombo Sri Lanka and Global Facilitation Unit for Underutilised Species*. Rome, Italy, p. 33. Available at: https://agris.fao.org/agris-search/search.do?recordID=QJ2007000030.

Johnson, LA (2000) 'Corn: The Major Cereals of the Americas', in K, K. and JG, P. (eds) *Handbook of Cereal Science and Technology*. 2nd Editio. New York: Marcel Dekker.

Jury, Mark R. (2018) 'Climate trends across south africa since 1980', *Water SA*. South African Water Research Commission, 44(2), pp. 297–307. doi: 10.4314/wsa.v44i2.15.

Kachiguma, Nathan Aliel, Mwase, Weston, Maliro, Moses & Damaliphetsa, Alex (2015) 'Chemical and Mineral Composition of Amaranth (Amaranthus L.) Species Collected From Central Malawi', *Journal of Food Research*, 4(4), p. 92. doi: 10.5539/jfr.v4n4p92.

Kamotho, Sylviah N., Kyallo, F. M. & Sila, D. N. (2017) 'Biofortification of maize flour with grain amaranth for improved nutrition', *African Journal of Food, Agriculture, Nutrition and Development*, 17(4), pp. 12574–12588. doi: 10.18697/ajfand.80.15945.

Kariuki, Stephen, Sila, Daniel & Kenji, Glaston (2013) 'Nutritional Profile of Amaranth Grain Varieties Grown in Kenya', *Food Science and Quality Management*, 17. Available at: www.iiste.org.

Kauffman, Charles S. & Weber, Leon E. (1990) 'Grain Amaranth', in Janick, J. and Simon, J. E. (eds) *Advances in new crops*. Portland, OR.: Timber Press. Available at: https://hort.purdue.edu/newcrop/proceedings1990/V1-127.html.

Khanam, Umma Khair Salma & Oba, Shinya (2013) 'Bioactive substances in leaves of two amaranth species, Amaranthus tricolor and A. hypochondriacus', *Canadian Journal of Plant Science*, 93(1), pp. 47–58. doi: 10.4141/CJPS2012-117.

Kigel, Jaime (2018) 'Development and ecophysiology of amaranths', in *Amaranth Biology, Chemistry, and Technology*. CRC Press, pp. 39–73. doi: 10.1201/9781351069601.

Kraujalis, Paulius, Venskutonis, Petras R., Kraujalienė, Vaida & Pukalskas, Audrius (2013) 'Antioxidant Properties and Preliminary Evaluation of Phytochemical Composition of Different Anatomical Parts of

Amaranth', *Plant Foods for Human Nutrition*. Kluwer Academic Publishers, 68(3), pp. 322–328. doi: 10.1007/s11130-013-0375-8.

Kumar, Maurya Neelesh & Arya, Pratibha (2018) 'Amaranthus grain nutritional benefits: A review', *Journal of Pharmacognosy and Phytochemistry*, 7(2), pp. 2258–2262. Available at: http://www.phytojournal.com/archives/2018/vol7issue2/PartAF/7-2-268-836.pdf.

Mabhaudhi, Tafadzwanashe, Chibarabada, Tendai, Chimonyo, Vimbayi, Murugani, Vongai, Pereira, Laura, Sobratee, Nafiisa, Govender, Laurencia, Slotow, Rob & Modi, Albert (2018) 'Mainstreaming Underutilized Indigenous and Traditional Crops into Food Systems: A South African Perspective', *Sustainability*, 11(1), p. 172. doi: 10.3390/su11010172.

Maboko, M. M. & Du Plooy, C. P. (2012) 'Effect of plant density and harvesting method on yield components of hydroponically grown amaranth', in *Acta Horticulturae*. International Society for Horticultural Science, pp. 415–421. doi: 10.17660/ActaHortic.2012.947.54.

Macharia-Mutie, Catherine W., van de Wiel, Anne M., Moreno-Londono, Ana M., Mwangi, Alice M. & Brouwer, Inge D. (2011) 'Sensory acceptability and factors predicting the consumption of grain amaranth in Kenya', *Ecology of Food and Nutrition*, 50(5), pp. 375–392. doi: 10.1080/03670244.2011.604584.

Macharia-Mutie, Catherine W., Moretti, Diego, Van den Briel, Natalie, Omusundi, Agnes M., Mwangi, Alice M., Kok, Frans J., Zimmermann, Michael B. & Brouwer, Inge D. (2012) 'Maize porridge enriched with a micronutrient powder containing low-dose iron as NaFeEDTA but not amaranth grain flour reduces anemia and iron deficiency in kenyan preschool children', *Journal of Nutrition*. J Nutr, 142(9), pp. 1756–1763. doi: 10.3945/jn.112.157578.

MacHaria-Mutie, Catherine W., Omusundi, Agnes M., Mwai, John M., Mwangi, Alice M. & Brouwer, Inge D. (2013) 'Simulation of the effect of maize porridge fortified with grain amaranth or micronutrient powder containing NaFeEDTA on iron intake and status in Kenyan children', *Public Health Nutrition*. Cambridge University Press, 16(9), pp. 1605–1613. doi: 10.1017/S1368980012005174.

Makobo, N. D., Shoko, M. D. & Mtaita, T. A. (2010) 'Nutrient Content of Vegetable Amaranth (Amaranths cruentus L.) At Different Harvesting Stages', *World Journal of Agricultural Sciences*, 6(3), pp. 285–289. Available at: https://pdfs.semanticscholar.org/6c11/819dc0c5b42e35ab1a83d006de6bfadc7717.pdf.

Maseko, Innocent, Mabhaudhi, Tafadzwanashe, Tesfay, Samson, Araya, Hintsa Tesfamicael, Fezzehazion, Melake & Du Plooy, Christian Phillipus (2017) 'African leafy vegetables: A review of status, production and utilization in South Africa', *Sustainability (Switzerland)*, 10(1), pp. 1–16. doi: 10.3390/su10010016.

Mayo Clinic (2017) *Zinc*, *Drugs & Supplement A-Z*. Available at: https://www.mayoclinic.org/drugs-supplements-zinc/art-20366112 (Accessed: 30 May 2020).

Mbwambo, O., Abukutsa Onyango, M. O., Dinssa, F. F. & Ojiewo, C. (2015) 'Performances of elite amaranth genotypes in grain and leaf yields in Northern Tanzania', *Journal of Horticulture and Forestry*, 7(2), pp. 16–23. doi: 10.5897/jhf2014.0377.

Mchiza, Zandile J., Steyn, Nelia P., Hill, Jillian, Kruger, Annamarie, Schönfeldt, Hettie, Nel, Johanna & Wentzel-Viljoen, Edelweiss (2015) 'A Review of Dietary Surveys in the Adult South African Population from 2000 to 2015', *Nutrients*, 7, pp. 8227–8250. doi: 10.3390/nu7095389.

Medoua, Gabriel Nama & Oldewage-Theron, Wilna H. (2014) 'Effect of drying and cooking on nutritional value and antioxidant capacity of morogo (Amaranthus hybridus) a traditional leafy vegetable grown in South Africa', *Journal of Food Science and Technology*. Springer India, 51(4), pp. 736–742. doi: 10.1007/s13197-011-0560-4.

Meybeck, Alexandre, Laval, Elizabeth, Lévesque, Rachel & Parent, Geneviève (2017) *Food Security and Nutrition in the Age of Climate Change.Proceedings of the International Symposium organized by the Government of Québec in collaboration with FAO. Québec City, Proceedings of the International Symposium organized by the Government of Québec in collaboration with FAO. Québec City*. Rome: FAO.

Mlakar, SG, Turinek, Matjaž & Jakop, Manfred (2009) 'Nutrition value and use of grain amaranth: potential future application in bread making', *Agricultura*, 6, pp. 43–53. doi: 10.1016/j.learninstruc.2016.07.002.

MRC Vitamin Study Research Group (1991) 'Prevention of neural tube defects: Results of the Medical Research Council Vitamin Study', *The Lancet*, 338(8760), pp. 131–137. doi: 10.1016/0140-6736(91)90133-A.

Mwanri, A. W., Mamboleo, T. F., Msuya, J. M. & Gowele, V. F. (2018) 'Oxalate, phytate and nitrate content in African nightshade, spider plant and amaranths at different stages of maturity', *African Journal of Food Science*, 12(11), pp. 316–322. doi: 10.5897/ajfs2018.1735.

Myers, Robert L. (2001) 'A Lost Crop of the Americas How to Grow Grain Amaranth'. Columbia, MO: Jefferson Institute, pp. 4–7.

NAFIS (2019) *Harvesting & Marketing*, *Market Information on Amaranth*. Available at: http://www.nafis.go.ke/vegetables/grain-amaranth/harvesting-marketing/ (Accessed: 1 June 2020).

National Osteoporosis Foundation of South Africa (2020) *The stark reality of South Africa's low calcium intake*. National Oosteoporosis Foundation of South Africa (NOFSA). Available at: https://osteoporosis.org.za/the-stark-reality-of-south-africas-low-calcium-intake/ (Accessed: 28 May 2020).

National Research Council (1984) *Amaranth: Modern Prospects for an Ancient crop*. Washington, DC. National Acadamy Press

National Research Council (2006) *Lost Crops of Africa: Volume II: Vegetables*. Washington, D.C., USA: National Academies Press. doi: 10.17226/11763.

Novotny, Janet A. (2011) 'Molybdenum Nutriture in Humans', *Journal of Evidence-Based Complementary & Alternative Medicine*. SAGE PublicationsSage CA: Los Angeles, CA, 16(3), pp. 164–168. doi: 10.1177/2156587211406732.

Nyonje, Winnie Akiniyi (2015) *Nutrients , anti-nutrients and phytochemical evaluation of ten vegetable amaranth (Amaranthus spp .) Varieties at two stages of growth*. Jomo Kenyatta University of Agriculture and Technology.

Nzomo, E. .., Ariyawardana, A., Silas, D. .. & Shellahewa, J. .. (2015) 'Reaping the potential benefits of amaranth: value chain challenges ahead for Kenya', *Acta Horticulturae (ISHS)*, 1102(24), pp. 191–198. doi: DOI: 10.17660/ActaHortic.2015.1102.24.

Odhav, B., Beekrum, S., Akula, Us & Baijnath, H. (2007) 'Preliminary assessment of nutritional value of traditional leafy vegetables in KwaZulu-Natal, South Africa', *Journal of Food Composition and Analysis*, 20(5), pp. 430–435. doi: 10.1016/j.jfca.2006.04.015.

Omamt, E. N., Hammes, P. S. & Robbertse, P. J. (2006) 'Differences in salinity tolerance for growth and water-use efficiency in some amaranth (Amaranthus spp.) genotypes', *New Zealand Journal of Crop and Horticultural Science*, 34(1), pp. 11–22. doi: 10.1080/01140671.2006.9514382.

Orsango, Alemselam Zebdewos, Loha, Eskindir, Lindtjørn, Bernt & Engebretsen, Ingunn Marie S. (2020) 'Efficacy of processed amaranth-containing bread compared to maize bread on hemoglobin, anemia and iron deficiency anemia prevalence among two-to-five year-old anemic children in Southern Ethiopia: A cluster randomized controlled trial', *PLoS ONE*. Public Library of Science, 15(9 September). doi: 10.1371/journal.pone.0239192.

Pereira, Laura M. (2014) *The Future of South Africa ' s Food System : What is research telling us?*, *South African Food Lab*. Stellenbosch, South Africa: Southern Africa Food Lab.

Peter, Kavita & Gandhi, Puneet (2017) 'Rediscovering the therapeutic potential of Amaranthus species : A review', *Egyptian Journal of Basic and Applied Sciences*. Mansoura University, 4(3), pp. 196–205. doi: 10.1016/j.ejbas.2017.05.001.

Philip, Kate (2010) 'Inequality and Economic Marginalisation How the Structure of the Economy Impacts on Opportunities on the Margins', *Democracy and Development*, 14. Available at: www.ldd.org.za

(Accessed: 3 June 2020).

Pillay, Kirthee (2011) 'Nutritional Quality and Consumer Acceptability of Provitamin A-Biofortified Maize', *Doctorate Thesis in the Discipline of Dietetics and Human Nutrition; School of Agricultural Sciences and Agribusiness, Faculty of Science and Agriculture, University of KwaZulu-Natal*. Peitermaritzburg: South Africa..

Písaříková, B., Zralý, Z., Kráčmar, S., Trčková, M. & Herzig, I. (2005) 'Nutritional value of amaranth (genus Amaranthus L.) grain in diets for broiler chickens', *Czech J. Anim. Sci*, 50(12), pp. 568–573. Available at: https://www.agriculturejournals.cz/publicFiles/53035.pdf.

Plumlee, Konnie H. (2004) *Clinical Veterinary Toxicology*. Amsterdam, Netherlands: Elsevier Health Sciences.

Rastogi, Anu & Shukla, Sudhir (2013) 'Amaranth: A New Millennium Crop of Nutraceutical Values', *Critical Reviews in Food Science and Nutrition*, 53(2), pp. 109–125. doi: 10.1080/10408398.2010.517876.

Rensburg, Jansen van, Averbeke, W. van, Slabbert, R., Faber, M., Jaarsveld, P. van, Heerden, I. van, Wenhold, F. & Oelofse, A. (2007) 'African leafy vegetables in South Africa', *Water South Africa*, 33(3), pp. 317–326.

Reports and Data (2020) *Amaranth Market Size & Share | Trends & Analysis, 2020-2027*, *Amaranth Market By Extraction Type, By Product Type, By Application, And Segment Forecasts, 2017-2027*. Available at: https://www.reportsanddata.com/report-detail/amaranth-market (Accessed: 1 June 2020).

Ronska, Natalia (2019) *HOW AMARANTH OIL HAS CHANGED THE MARKET OF COSMETIC PRODUCTS*. Available at: http://amaranth-health.com/en/how-amaranth-oil-has-changed-the-market-of-cosmetic-products/ (Accessed: 17 May 2020).

Rosenberg, Irwin H. & Rand, William M. (2009) 'Dietary management of moderate malnutrition: Time for a change', *Food and Nutrition Bulletin*, 30(3). Available at: http://www.ennonline. (Accessed: 3 June 2020).

Santra, D. K. & Schoenlechner, R. (2016) 'Amaranth Part 2-Sustainability, Processing, and Applications of Amaranth', *Sustainable Protein Sources*. Elsevier Inc., pp. 257–264. doi: 10.1016/B978-0-12-802778-3.00016-0.

Saubhik, Das (2016) 'Amaranthus: A Promising Crop of Future', *Springer Science*. Singapore, p. 208 pp. doi: DOI 10.1007/978-981-10-1469-7.

Sauer, Jonathan D. (1988) *Plant Migration, the Dynamics of Geographic Patterning in Seed Plant Species*. California: University of California Press.

Schoenlechner, Regine, Siebenhandl, Susanne & Berghofer, Emmerich (2008) 'Pseudocereals', in Arendt, E. K. and Bello, F. D. (eds) *Gluten-Free Cereal Products and Beverages*. First edit. Ireland: First edition 2008, pp. 151–160.

Senyolo, Grany M., Wale, Edilegnaw & Ortmann, Gerald F. (2017) 'Analysing the value chain for African leafy vegetables in Limpopo Province, South Africa', *Cogent Arts & Humanities*. doi: 10.1080/23311886.2018.1509417.

Sharma, Aniket (2019) *Amaranth Market Size & Share | Industry Analysis Report, 2019-2025*, *Grand View Research*. Available at: https://www.grandviewresearch.com/industry-analysis/amaranth-market (Accessed: 1 June 2020).

Shelef, Oren, Weisberg, Peter J. & Provenza, Frederick D. (2017) 'The value of native plants and local production in an era of global agriculture', *Frontiers in Plant Science*, 8(December). doi: 10.3389/fpls.2017.02069.

Shisana, O., Labadarios, D., Rehle, T., Simbayi, L., Zuma, K., Dhansay, A., Reddy, P., Parker, W., Hoosain, E., Naidoo, P., Hongoro, C., Mchiza, Z., Steyn, NP, Dwane, N., Makoae, M., Maluleke, T., Ramlagan, S., Zungu, N., Evans, MG, Jacobs, L., Faber, M. & SANHANES-1 Team (2013) 'South African National Health and Nutrition Examination Survey (SANHANES-1)'. Cape Town: HSRC Press. doi: 10.1007/s12160-009-

9099-2.

Siebert, Anne (2020) 'Transforming urban food systems in South Africa: unfolding food sovereignty in the city', *Journal of Peasant Studies*. Taylor & Francis, 47(2), pp. 401–419. doi: 10.1080/03066150.2018.1543275.

Stegelmeier, Bryan L., Field, Reuel, Panter, Kip E., Hall, Jeffery O., Welch, Kevin D., Pfister, James A., Gardner, Dale R., Lee, Stephen T., Colegate, Steve, Davis, T. Zane, Green, Benjamin T. & Cook, Daniel (2013) 'Selected Poisonous Plants Affecting Animal and Human Health', in Haschek, W. et al. (eds) *Haschek and Rousseaux's Handbook of Toxicologic Pathology*. Third Edit. Cambridge, Massachusetts: Academy Press, pp. 1259–1314. doi: 10.1016/B978-0-12-415759-0.00040-6.

Steyn, NP, Nel, JH, Nantel, G., Kennedy, G. & Labadarios, D. (2006) 'Food variety and dietary diversity scores in children: are they good indicators of dietary adequacy?', *Public Health Nutrition*. Cambridge University Press (CUP), 9(5), pp. 644–650. doi: 10.1079/phn2005912.

Suma, S., Ambika, S. R., Kazinczii, G. & S.S.Narwal. (2002) 'Allelopathic plants. 6. Amaranthus spp.', *AllelopathyJ ournal*, 10(1), pp. 1–12.

Taleni, Vuyiswa, Nyoni, Phefumula & Goduka, Nomalungelo (2012) *People's perceptions on indigenous leafy vegetables: A case study of Mantusini Location of the Port St Johns Local Municipality, in the Eastern Cape, South Africa*. Available at: https://www.mandelainitiative.org.za/images/docs/2012/papers/260_Taleni_Peoples perceptions on indigenous leafy vegetables - a case study of Mantusini location of the Port St JOhns Local MUnicipality.pdf.

Tawodzera, Godfrey & Crush, Jonathan (2019) *Inclusive Growth and the Informal Food Sector in Cape Town, South Africa*. Edited by J. Crush and L. Riley. Waterloo, Canada: Published by the Hungry Cities Partnership.

Termeer, Catrien J. A. M., Drimie, Scott, Ingram, John, Pereira, Laura & Whittingham, Mark J. (2018) 'A diagnostic framework for food system governance arrangements: The case of South Africa', *NJAS - Wageningen Journal of Life Sciences*. Elsevier, 84(August 2017), pp. 85–93. doi: 10.1016/j.njas.2017.08.001.

Thandeka, N., Sithole, N. & Thamaga-Chitja, J.M Makanda, I. (2011) 'The role of traditional leafy vegetables in household food security in rural KwaZulu-Natal', *Indilinga – African journal of indigenous knowledge systems*, 10(2), pp. 19–5209.

Tibagonzeka, J., Wambete, J., Muyinda, AM, Nakimbugwe, D. & Muyonga John, H. (2014) 'Acceptability and nutritional contribution of grain amaranth recipes in Uganda', *African Journal of Food, Agriculture, Nutrition and Development*, 14(3), pp. 8979–8997.

U.S. Department of Health and Human Services and U.S. Department of Agriculture (2015) *2015-2020 Dietary Guidelines for Americans*. 8th Editio. Available at: http://health.gov/dietaryguidelines/2015/guidelines/.

Umaru, A. H., R, Adamu, D, Dahiru & M, S. Nadro (2016) 'Levels of antinutritional factors in some wild edible fruits of Northern Nigeria', *African Journal of Biotechnology*, 6(16), pp. 1935–1938. doi: 10.5897/ajb2007.000-2294.

URT (2017) *2016/17 Annual Agriculture Sample Survey*. Tanzania. Available at: https://nbs.go.tz/nbs/takwimu/Agriculture/2016_17_AASS_ report.pdf.

Valencia-Chamorro, S. A. (2003) 'Quinoa', *Encyclopedia of Food Sciences and Nutrition*. Academic Press, pp. 4895–4902. doi: 10.1016/B0-12-227055-X/00995-0.

Van der Merwe, J. .., Cloete, P. C. .. and & van der Hoeven, M. (2016) 'Promoting food security through indigenous and traditional food crops', *Agroecology and Sustainable Food Systems,* 40(8), pp. 830–847.

Venskutonis, Petras R. & Kraujalis, Paulius (2013) 'Nutritional Components of Amaranth Seeds and Vegetables: A Review on Composition, Properties, and Uses', *Comprehensive Reviews in Food Science and Food Safety*, 12(4), pp. 381–412. doi: 10.1111/1541-4337.12021.

Vorster, HH, Badham, JB & Venter, CS (2013) 'An introduction to the revised food-based dietary guidelines for South Africa', *S Afr J Clin Nutr*, 23(6), pp. 1–164. Available at: www.sajcn.co.za (Accessed: 22 July 2019).

Voster, H. .. Ineke, Willem, Jansen van Rensburg, J.J.B, Van Zijl & Sonja, L. Venter (2007) 'Re-Creating Awareness of Traditional Leafy Vegetables in Communities', *Africa Journal of Food Agriculture Nutrition and Development*, 7(4), pp. 1–3.

Wanjala, W. G., Onyango, Makayoto, M. & Onyango, C. (2016) 'Indigenous technical knowledge and formulations of thick (ugali) and thin (uji) porridges consumed in Kenya', *African Journal of Food Science*, 10(12), pp. 385–396. doi: 10.5897/AJFS2016.

WHO (2007) *Protein and amino acid requirements in human nutrition: Report of a joint FAO/WHO/UNU expert consultation*. Geneva, Switzerland. Available at: www.who.int/bookorders (Accessed: 20 May 2019).

Van Wilgen, Nicola J., Goodall, Victoria, Holness, Stephen, Chown, Steven L. & McGeoch, Melodie A. (2016) 'Rising temperatures and changing rainfall patterns in South Africa's national parks', *International Journal of Climatology*. John Wiley and Sons Ltd, 36(2), pp. 706–721. doi: 10.1002/joc.4377.

Yadav, Shashi Kala & Sehgal, Salil (1995) 'Effect of home processing on ascorbic acid and β-carotene content of spinach (Spinacia oleracia) and amaranth (Amaranthus tricolor) leaves', *Plant Foods for Human Nutrition*. Kluwer Academic Publishers, 47(2), pp. 125–131. doi: 10.1007/BF01089261.

Chapter 3

3. Understanding consumer knowledge and perceptions of amaranth

3.1 Introduction

Over the years, there has been a global increase in awareness and consumption of underutilised indigenous foods, wild and forgotten foods (FAO, 2013). With an increasing rate of hunger and environmental degradation at national (Shisana *et al.*, 2013; Oxfam, 2014) and global levels (FAO, IFAD, UNICEF, WFP, WHO, 2019), most countries are seeking for ways to achieve food and nutrition security and at the same time sustainable food production. There is an increasing shift towards indigenous and traditional foods crops (ITFCs) as we see countries mobilising local biodiversity for a sustainable future.

Some of these ITFCs include ancient grains such as amaranth, which are labelled as 'super foods' due to their exceptional nutritional profiles (Saubhik, 2016; Ekesa, 2017). This includes a high micronutrient content (essential vitamins and minerals), high-quality amino-acid profile as well as health-promoting (nutraceutical) attributes of the crop (Singh & Singh, 2011; D'Amico & Schoenlechner, 2017). While strides have been made in other countries to increase production and utilisation of amaranth thereby making it more mainstream (Chemining'wa *et al.*, 2016), South Africa still lags despite amaranth being one of the most common indigenous crops in the country (DAFF, 2010). Also, while it is commonly known as a leafy vegetable, the fact that it produces grains is often neglected, and the grain usage is uncommon. A lot of studies carried out on amaranth are usually focused on the leaves and often are not exclusive to amaranth alone but carried out as a part of the collective 'African leafy vegetables' which includes a cocktail of indigenous vegetables (Ineke *et al.*, 2007; Rensburg *et al.*, 2007; Shiundu & Oniang'o, 2007; Taruvinga & Nengovhela, 2015; Senyolo *et al.*, 2017; Kansiime *et al.*, 2018). Hence, few stand-alone studies on amaranth as a leafy vegetable and even less common are studies on the grains.

It is clear from the literature that consumption of amaranth is greatly beneficial and its addition to a staple food product could enhance its nutritional value, in addition to its desirable agronomic traits that promote sustainable food production such as drought and heat tolerance (Omamt *et al.*, 2006; Vorster *et al.*, 2013). Therefore, the need to increase its consumption (especially amongst the food insecure) at a national level and make it more mainstream cannot be

overemphasised. But to effectively encourage people to consume amaranth, it is good to understand how they are currently interacting with the plant, that is in terms of their perception, consumption/utilisation (or lack of), production, processing and marketing of the crop. This will provide a picture of how things are and provide insight to identify the different areas that require intervention to make the crop more mainstream, amid reports that its availability and consumption are declining. Therefore, this chapter aims to assess consumer knowledge, perception, and consumption dynamics of amaranth leaves and grain. It goes further to explore the areas of production, availability market and value chains linked with amaranth.

3.2 Methods

3.2.1 Study area

The study was conducted across four rural (4) communities the Kwazulu-Natal province; these are Swayimane, Nhlazuka, Tugela Ferry and Umbumbulu. Kwazulu-Natal province was selected for the study because it is one location where amaranth grows wildly in South Africa. These districts were particularly chosen because they are areas of ongoing research for the Sustainable and Healthy Food Systems (SHEFS) and provide a good entry point for any study on indigenous foods. Farming is the predominant occupation in these areas, and a large portion of the land area is used for subsistence agricultural activities (Pauw, 2005)**.** Therefore, most people within these districts depend on their farm produce for food. Since amaranth occurs wildly, they are most likely to have a higher interaction with and an understanding of the plant.

Swayimane and Nhlazuka communities are both located in the uMgungundlovu district of the province. Swayimane is a part of the uMshwathi local municipality and is characterised by good rainfall (500 to 800 mm/annum), predominant fog and deep soils (Adaptation Fund, 2014). Nhlazuka is a community within Richmond local municipality of the district. It is unique because it is an elevated topography. The village settlement sits on steep hills with a gradient steeper than 1 meter in 3 metres (1:3), standing high above the surrounding area with small summit area, steep slopes. Tugela Ferry is a community in the Msinga local municipality, a part of the uMzinyathi district located in the northern part of KwaZulu-Natal. Msinga is predominantly mountainous, with rolling hills, loose stones and rocks, which make it difficult for farming, the area is subjected to water shortages, high soil erosion and low land carrying capacity (Institute of Natural Resources 2004). Umbumbulu is a rural community in the eThekwini Metropolitan Municipality, it is about 40 kilometres away from Durban (see Figure 3.1 below).

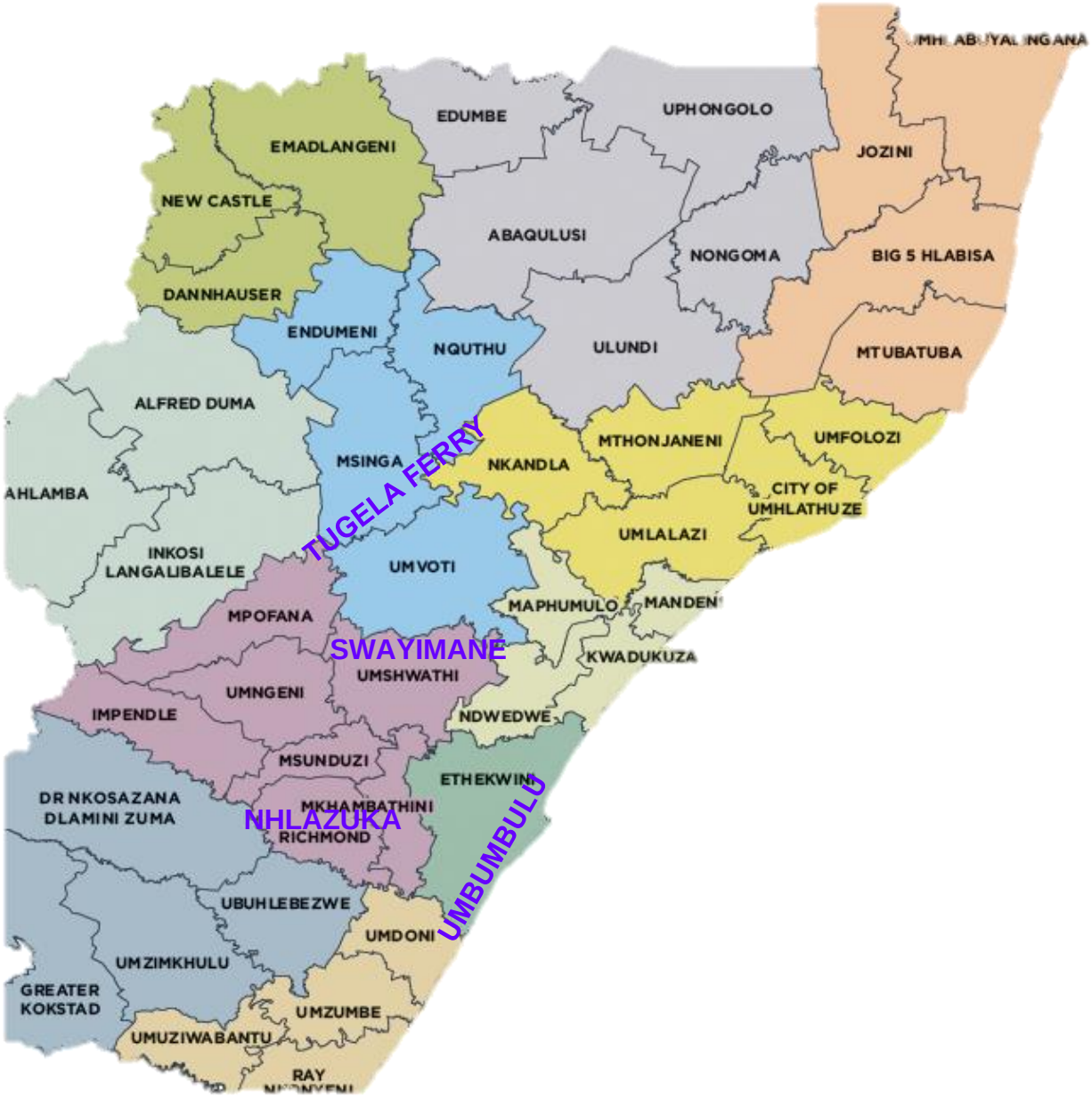

Figure 3.1: A map of Kwazulu-Natal Municipalities

Source: municipalities.co.za
https://municipalities.co.za/img/provinces/kwa_zulu_natal_municipalities_map.png

3.2.2 Study population

A total of 108 randomly selected farming individuals participated in the study. Due to the location of the study, participants were rural and for the most part, subsistence farmers. Some owned only small gardens and while others had larger farms and made earnings from their crop yields. Extension workers from the University of Kwazulu-Natal assisted in recruiting and selecting the participants.

3.2.3 Data collection

Phase 1: Qualitative household survey and focus group discussions

The study was carried out in two stages, the first stage of the study was a focus group discussion and qualitative survey consisting of semi-structured interviews with participants. The focus group discussions were conducted first, and following the feedback and data patterns obtained from the focus group discussion, household interviews were conducted. This was done in order to have more robust data on how different individuals and households interact with amaranth in terms of farming (production), purchase, consumption and other forms of utilisation of amaranth in the household.

A total of four (4) focus group discussion meetings were held, one in each survey site and each panel had between 10 and 12 individuals participating in the focus group discussions. Two trained facilitators from the University of Kwazulu-Natal facilitated the sessions which lasted for approximately 45 minutes. The sessions were recorded in isiZulu using a voice recorder and later transcribed and then translated into English.

For the household survey, a total of 63 households participated in the the study with one individual representing each household. There were 15 households from Swayimane, Umbumbulu and Nhlazuka, while Msinga had 18 households represented. Three trained data collectors also from the University of Kwazulu-Natal conducted the interviews in the local language isiZulu.

Other aspects of this phase included observations of participants farms and gardens and site visits to spaza shops and supermarkets within each study site, to determine the presence and by extension the availability of amaranth in participants gardens as well as in the markets.

Phase 2:

This phase involved identifying amaranth within the larger formal sector to have a balanced view of amaranth within the rural sphere and the urban sphere. A desk review was carried out to find relevant information about the presence of amaranth within the larger formal market sector. The review aimed to understand, identify, some of the actors, i.e. producers, processors, marketers (wholesalers, retailers) within the formal amaranth value chain as well as the amaranth products within these markets.

3.2.4 Ethical approval

Ethical approval for the study was obtained from the Stellenbosch University Research Ethics Committee (ANI-2018-8408) and the UKZN Humanities and Social Sciences Research Ethics

Committee/board (HSS0287/018). Before each interview and focus group discussion commenced, the interviewer or facilitator explained the nature and purpose of the study to the participants. Each participant then signed the consent form to indicate willingness to equired to participate in the study and to be recorded.

3.2.5 Data analysis

Qualitative data obtained from the interviews and focus group discussion were analysed using thematic content analysis. Field data were translated, transcribed on Microsoft Word and then migrated to a Microsoft Excel worksheet, where each participant's responses were recorded in a cell. The data was initially reviewed and sorted to remove any duplicate entries and then analysed with a view of assigning thematic areas to the data set. The data in each individual cell was reviewed by repeatedly reading each response/comment and comparing it with the researcher's field notes and a code assigned to it. Afterwards, recurring codes that commonly emerged from the interviews and focus groups were identified and organised into themes. Six thematic areas were identified from the coded data (i) Knowledge and perception of amaranth, (ii) Consumption of amaranth/household consumption, (iii) Consumption frequency of amaranth, (iv) Comparing amaranth to other foods (v) Amaranth food preparation, (vi) Amaranth farming. The themes were scrutinised to ensure that they work with the coded extracts and the entire data set, and then organised for final interpretation and conclusion. Quantitative data from the interviews were also analysed using Microsoft excel.

3.3 Results and Discussion

3.2.6 Demographics

A total of 108 individuals participated in the qualitative household survey and the focus group discussion (Table 3.1). The average age of participants was 52±1.05, and about 80% of the study participants were female (see Figure 3.2 and Figure 3.3).

Table 3.1: Study participants based on location

Location	Number of Participants		Total
	Household Surveys	Focus Group Discussion	
Swayimane	16	12	28
Nhlazuka	13	11	24
Umbumbulu	15	10	25
Msinga	19	12	31
Total			**108**

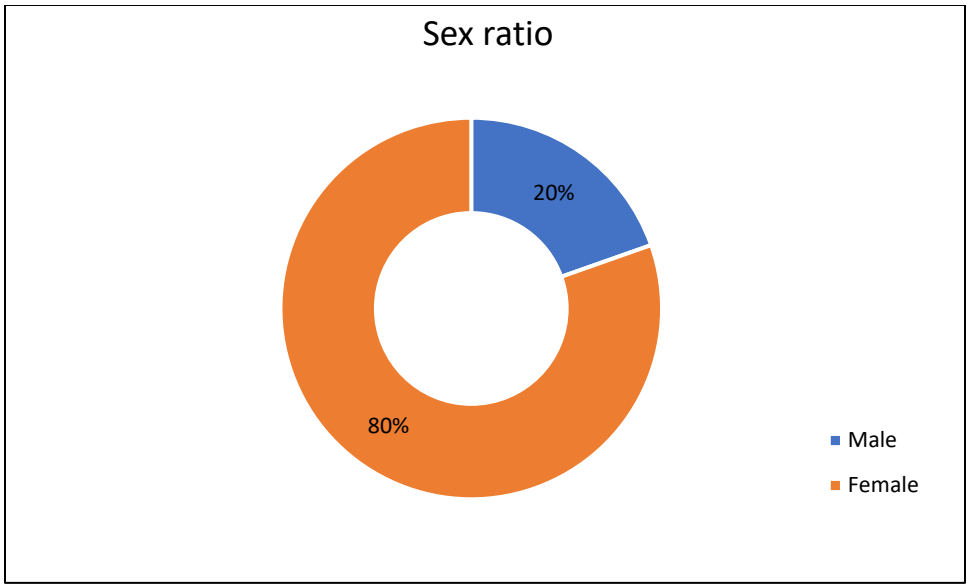

Figure 3.2:Participants sex n=108

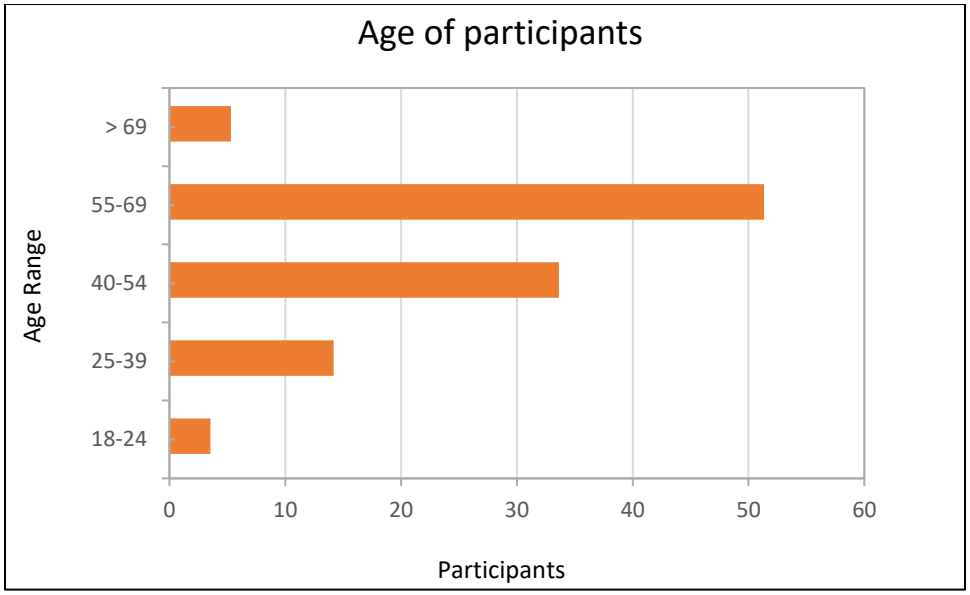

Figure 3.3: Participant's age n=108

In terms level of education, 25% of participants had no formal education while the majority of the participants (75%) had either primary school, secondary school or matric level education but none had any tertiary education. All the participants belonged to low-income families, more than half the participants reported a monthly household income of less than 3000 ZAR. Figures 3.4 and 3.5 provides a graphical representation of the respondent's education levels and monthly household income.

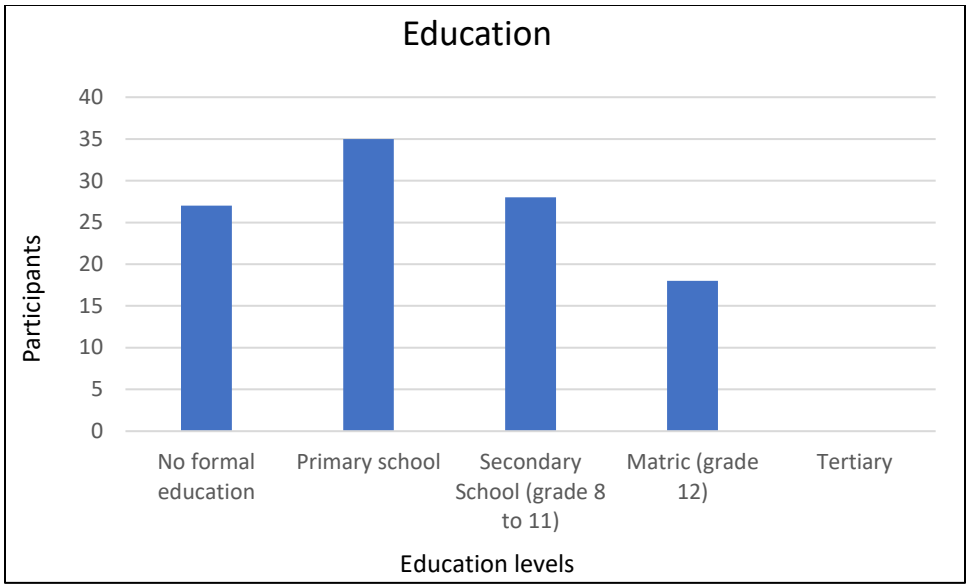

Figure 3.4: Breakdown of participant's education n=108

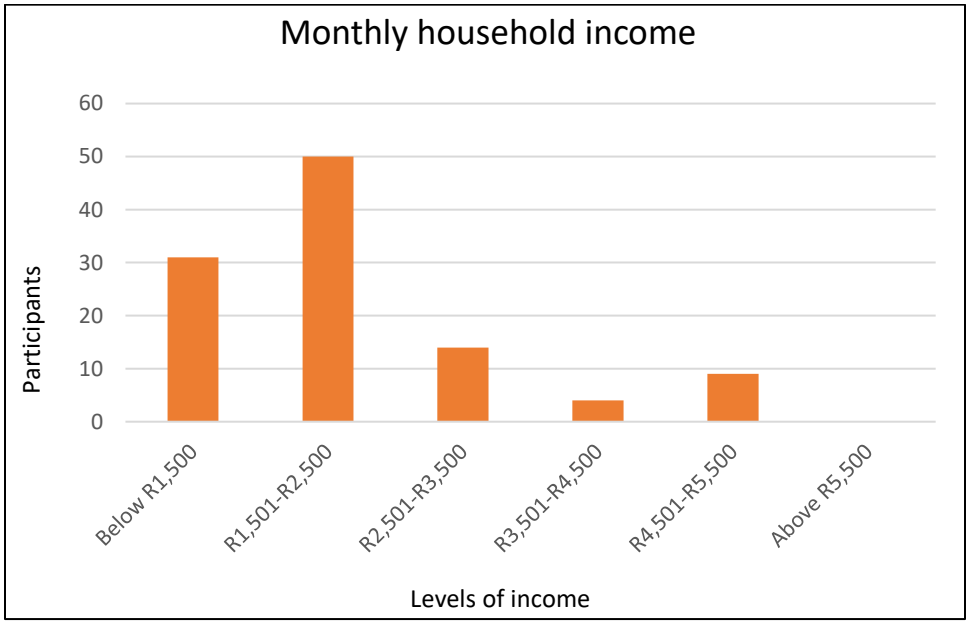

Figure 3.5: Breakdown of participant's income n=108

3.3.1 Common crops grown by participants

The crops commonly grown by participants in all the study locations were categorised into vegetables, tubers and grains/legume. Table 3.2 and Figure 3.6 below provides a breakdown of this categorisation. A majority of the crops planted by the respondents were vegetables with cabbage being the most common. Cabbage alone makes up for 26% of the entire crops reported by the participants. Crops like taro (amadumbe) and cowpeas, which can be considered

indigenous crops, accounted for only 6% of the total crops listed. This shows that the cultivation of indigenous crops is considerably less common than non-indigenous ones. Interestingly, none of the participants indicated that they grew amaranth or other indigenous leafy vegetables on their farms or gardens. Participants reported that the major factors influencing their decision for which crops planted are market demand, seed availability, and to a lesser degree, personal use. Hence, considering the limited cultivation of indigenous crops, it shows that there is less demand for indigenous crops in the market compared to non-indigenous ones, further proving how neglected amaranth is.

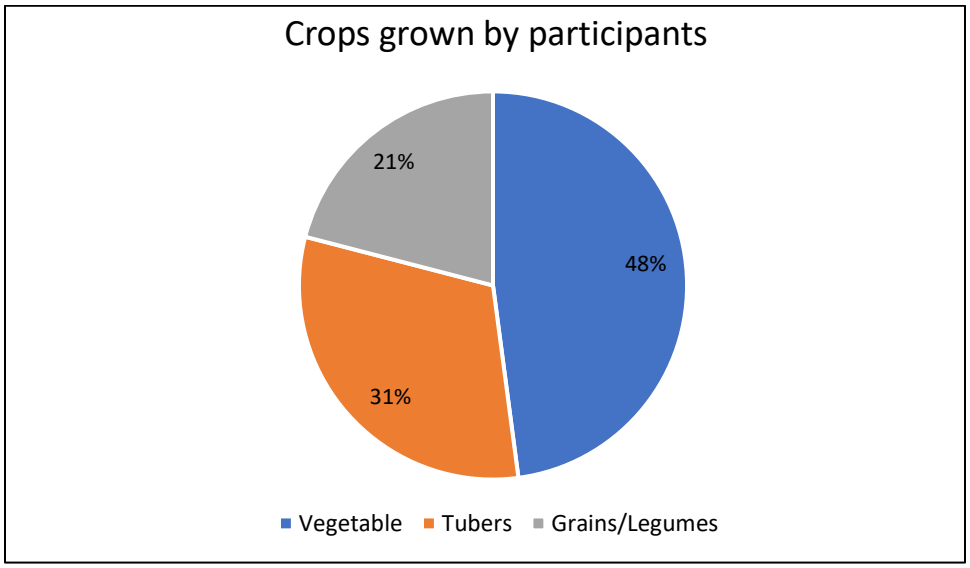

Figure 3.6: Common crops grown by participants

Table 3.2: Breakdown of common vegetables grown by study participants

Vegetables	Tubers	Grains/Legumes
▪ Cabbage	▪ Potatoes	▪ Maize
▪ Green pepper	▪ Sweet potatoes	▪ Beans
▪ Beetroot	▪ Taro/Amadumbe	▪ Cowpea
▪ Butternut		
▪ Carrot		
▪ Spinach		
▪ Tomatoes		
▪ Chilli		
▪ Eggplant		
▪ Onions		
▪ Lettuce		
▪ Broccoli		

3.3.2 Food patterns and food choices of participants

Information about the food pattern and food choices of participants was collected to understand the respondents' food environment; this is provided in Figure 3.7, Figure 3.8 and Table 3.3. It was important for the study to identify the common foods participants consumed and determine if amaranth was among the foods commonly consumed by participants. With the view to mainstreaming amaranth, this information will be an important factor in determining the kind of intervention recommended by the study. For example, if it is observed that participants consume amaranth as a major part of their diet, then it means amaranth is already mainstream, and there may be no need to encourage them to eat more. Suppose on the other hand the data shows that amaranth is not a major part of their diet, in that case, the study will need to explore further and provide recommendation for interventions to encourage them to consume more amaranth as a part of a healthy food system. However, it is good to note that information on food pattern alone does not provide the whole picture or as to why amaranth is or is not consumed.

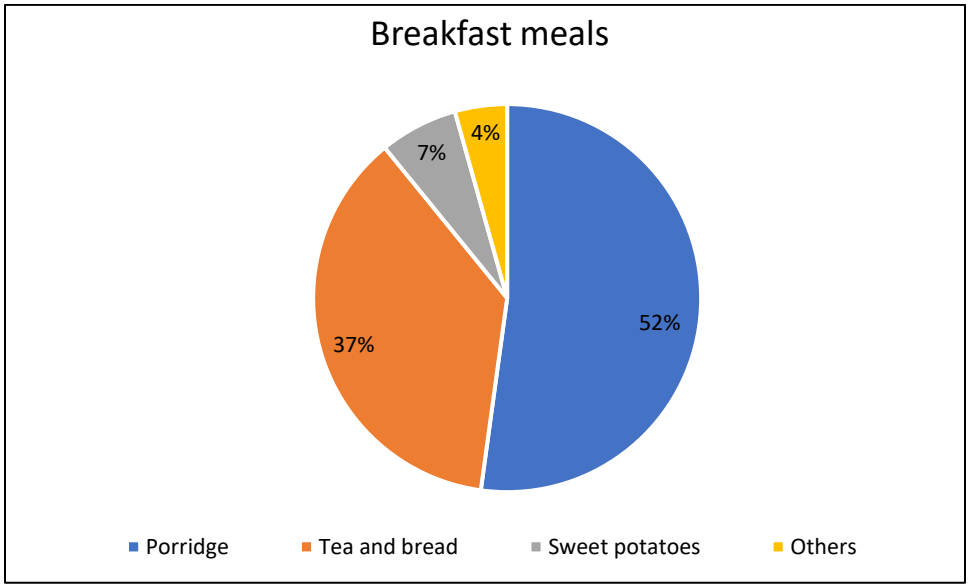

Figure 3.7: A breakdown of common breakfast consumed by participants

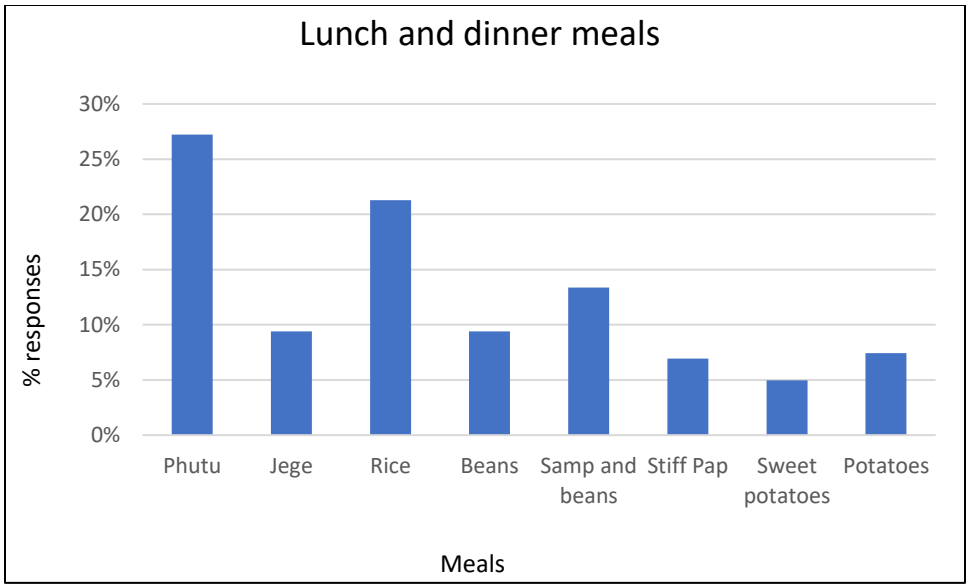

Figure 3.8: A breakdown of lunch and dinner meals consumed by participants n=100%

Table 3.3: Breakdown of meals consumed by participants

Breakfast	Lunch and Dinner
▪ Maize meal porridge prepared with sugar, milk, margarine, lemon or vinegar ▪ Bread and tea with milk, margarine ▪ Sweet potatoes ▪ Others: Weetbix, butternut, leftovers from previous day's dinner	▪ *Phutu*, with cabbage, spinach maas, imfino, amaranth ▪ Stiff pap with cabbage, spinach maas, imfino, amaranth ▪ Rice with curry, vegetables (carrots, green peppers) ▪ Samp and beans ▪ Potatoes with curry ▪ Bean curry ▪ Amadumbe

From the result above, it can be seen that maize and rice are the most commonly consumed grains. Maize in the form of porridge makes up 52% of breakfast and 48% of lunch and dinner in the form of *phutu*, stiff pap and samp. Rice makes up for 21% of lunch and dinner consumed. None of the participants reported that they consume amaranth grain as a part of their everyday diet. *Phutu* and stiff pap were commonly consumed with a vegetable side dish or relish. Among the side dishes consumed, 51% was cabbage, 20% spinach, 14% maas, 9% amaranth and 6% imfino (imfino here refers to other indigenous leafy vegetables that are not amaranth). This shows that the consumption of amaranth is considerably less than cabbage and spinach, further evidence that consumption of amaranth and other indigenous leafy vegetables is declining

(Rensburg *et al.*, 2007; Thandeka *et al.*, 2011). However, the higher consumption of cabbage is expected, since there is a high production of cabbage compared to other vegetables by the respondents.

3.4 Findings on Amaranth

3.4.1 Knowledge and perception of amaranth

All participants knew amaranth, a major source of that knowledge were their parents, especially the mother, who taught them how to harvest, process, preserve and prepare amaranth. This shows that there is to some degree, transfer of indigenous knowledge regarding amaranth, and highlights the importance of indigenous knowledge systems to food security. Some participants, however, reported that they have tried teaching their children about the crop but are finding it difficult to transfer this knowledge to their children because they do not show interest in the plant and often refer to amaranth as old people's food. Direct quotes from participants include statements like *"they don't listen, and they say imfino is for old people", "the young ones say its weeds, they say we are eating weeds"*. This supports the findings of Masekoameng & Molotja, (2019), who reported that indigenous knowledge systems might soon disappear because younger generations do not see the relevance.

There is a high genetic and phenotypic variability among amaranth plants. Participants were able to describe the physical characteristics and phenotypic differences between the plant's different species, in terms of height, colour, stem, and leaves. However, most participants' knowledge of amaranth was limited to its use as a leafy vegetable and not a grain (pseudo-grain). Almost half (44%) of the respondents did not know that amaranth produces grains or seeds. Of those that knew it produces grains, 80% did not know that the grains were edible. One participant reported *"I see the seeds but I didn't know you can eat them".* The participant further explained that the amaranth growing in her garden produced black seeds which did not seem edible (see Figure 3.9). Although the lightly ivory coloured amaranth seem to be the most common grain type, amaranth comes in different shade coloured like brown, reddish and black (see chapter 2). Additionally, studies have shown that the black amaranth seeds contain twice as much fibre as the golden coloured one while being higher in antioxidants such as lignin but with lower protein digestibility (Pedersen *et al.*, 1987, 1990).

Figure 3.9: Participant in Swayimane showing the black amaranth seeds from her garden

The most common sub-themes that emerged around the area of knowledge and perception of amaranth were Food and Nutrition, Health-promoting, Cultivation, Weed and Others. Figure 3.10 shows a graphical presentation of the common themes identified. Forty percent of responses included the words “nutritious” “food” and “vegetable” in the description of the crop, recognising amaranth as an important source of food. Forty-two percent of the responses were around the cultivation (or rather the absence of it) and growth of the plant, which describes the plant as a volunteer crop with phrases like “*it grows on its own*”, *“it grows by itself”, “it grows naturally”, “it doesn’t need fertilizer or chemicals to grow”* etc. Amaranth is characterized as a volunteer crop (DAFF, 2010), volunteer plants are offspring of seed crops that come up in the field with no effort of planting, and although the biological basis of crop volunteerism is not well understood but it is likely that environmental factors induce increased seed shattering in the plants rather than retaining seed for harvesting (Gressel, 2005; Tzotzos *et al.*, 2009).

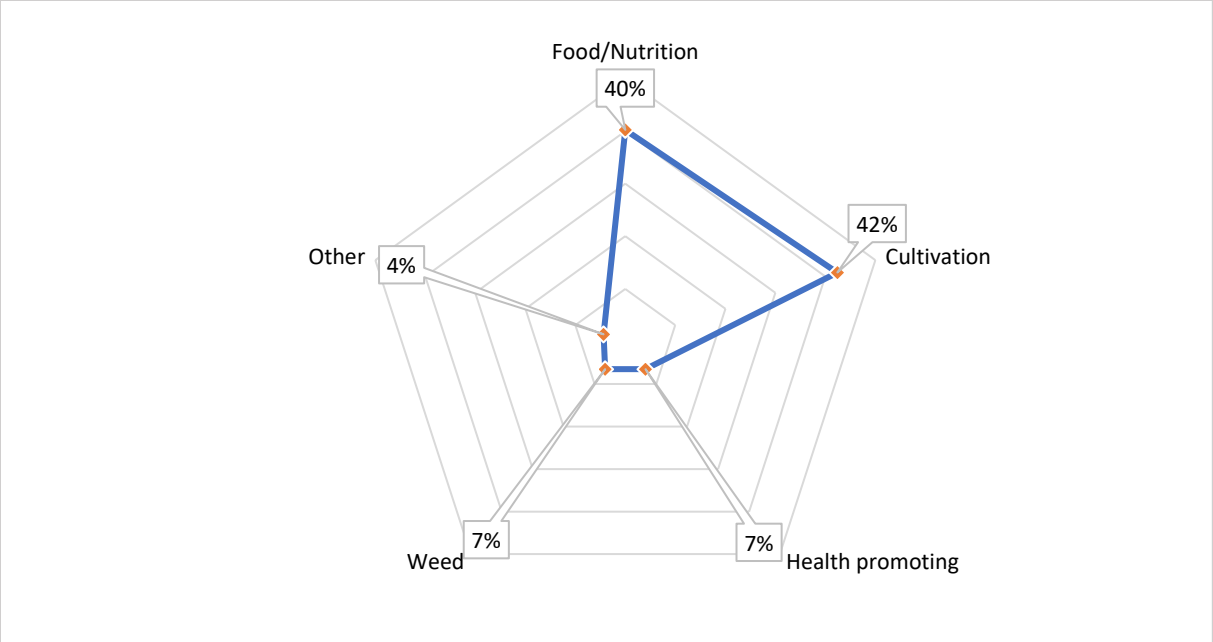

Figure 3.10: Knowledge and perception of amaranth

Seven percent of the responses describe amaranth as a "healthy" or "healthier" compared to other foods". This shows that some, albeit a small number of respondents' value amaranth as a health-promoting food. Only 7% of the responses had any reference to weed, indicating that only a few respondents experience it as weed and negatively perceived the crop.

As for the knowledge gap when it comes to the awareness about amaranth grains, participants response seems to suggest that a reason for the limited knowledge of the grains may be because the amaranth plant is often not left long enough on the farm/garden to produce grains. Amaranth leaves are known to turn fibrous and less palatable as it reaches reproductive stage at which point participants weed it out of their farms/gardens. Participants gave responses such as *"it flowers quickly during the winter and doesn't give much leaves, once it matures, I remove it", "amaranth is tastier when it is young, at early stages we harvest it for eating, but we remove it at mature stages"*, *"we first eat the leaves then we weed it but it's no stress because we know that it'll be back after few days after weeding it"*. This indicates that the participants have a decreased level of interaction with the plant once it has passed its vegetative stage, as the mature plant (in the reproductive stage) holds little to no value for them. Because of this limited interaction, participants do not have knowledge of the other parts of the plant like the seeds/grains, which is perhaps why some participants are not aware that amaranth produces edible grains.

Overall, the responses demonstrated a positive perception of amaranth. This could indicate that people's perception about the crop is becoming more positive, or as Weinberger, (2007) argues, their value is increasingly being recognised and appreciated.

3.4.2 Consumption of amaranth

All participants reported that they have consumed amaranth. Ninety-seven percent of the participants currently consume amaranth, while the remaining 3% say they use to eat it but they no longer eat it, with statements like *"I don't like the taste"* and *"it is bitter"* as reasons why they no longer consume it. Of those who consume it, 95% say that they enjoy eating it, 3% do not enjoy eating it, and 2% say they "maybe" enjoy eating it. As mentioned earlier, most respondents either did not know that amaranth produces grains, or that the grain was edible, and as such, 100% of respondents who consume amaranth eat only eat the leaves.

Participants gave several reasons as to why they consume amaranth, the major sub-themes identified around their reason for consumption of amaranth were "nutrition", "health and wellbeing", "food security", "taste" and "preference". Nutrition was cited as the primary reason for the consumption of amaranth, 26% of the responses had the word *"nutrition"* or its derivative (nutrient, nutritious, etc.), which means that respondents choose to consume amaranth of its perceived nutritional value. Figure 3.11 provides a breakdown of the major reasons participants gave for consuming amaranth.

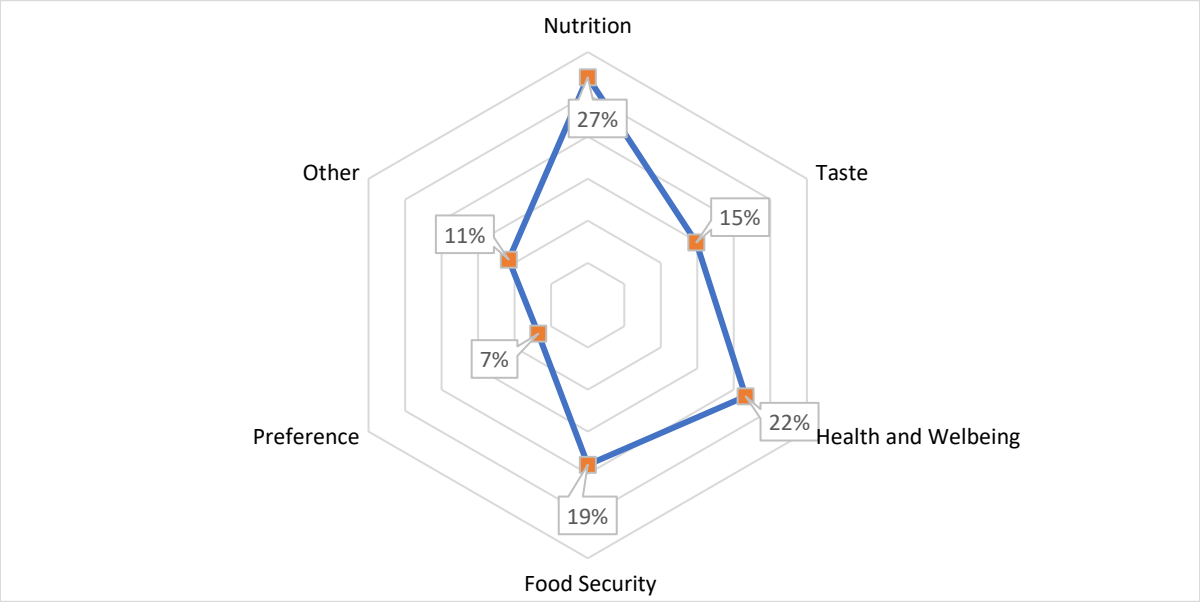

Figure 3.11: Reasons for consuming amaranth

Twenty-two percent of the responses given were centered around the health benefits of the plant, with responses like *"it is healthy" "amaranth is a healing herb", "Amaranthus for us is healthy, we like it more than any vegetables as it also lowers our blood sugar level".* This shows that amaranth is being recognized not just as food, but for its therapeutic benefits and as a tool to enhance health. According to the international diabetes federation (IDF), 12.8% of adults in South Africa are diabetic (IDF, 2020), and rural older women are at a higher risk for several non-communicable diseases (NCDs) like diabetes, hypertension, high cholesterol, (van Heerden *et al.*, 2017) etc. Studies have shown that amaranth has cardioprotective (lowering blood pressure and cholesterol) and anti-diabetic properties comparable to and sometimes more effective than the medications used to treat these diseases (Peter & Gandhi, 2017).

Nineteen percent of the responses were on food security; participants made statements like "*I eat it when food is not available*" and "*It is free food, sometimes that's the only option you have instead of going hungry*", *"it provides all the nutrients in times of scarcity",* indicating that they consume amaranth out of necessity and convenience rather than preference or taste. On the other hand, some of the responses indicated that participants consume amaranth particularly for its taste, 14% of the responses included the words *"tasty*" and *"delicious"* to describe why they consume amaranth. Some of the responses (7%) seem to infer that participants preferred amaranth to other vegetables. With statements like *"I prefer it", "If we had to choose between amaranth and other vegetables, we would choose amaranth because it's very nice".* For the category of responses titled other, participants gave responses like *"I eat amaranth because it is there"*, *"we eat amaranth because it is good for children", "because I grew up eating it".*

3.4.3 Household consumption of amaranth

Only 29% of the respondents indicated that some household members do not eat amaranth, most of which are the younger demographic. The respondents confirm that this was not peculiar to amaranth alone, but many other traditional leafy vegetables. The reason the respondents gave is that children do not find amaranth palatable and hence do not like eating it. Participants made statements like *"the young ones don't like it, they say it doesn't taste nice", "The children don't like to eat it, they prefer eating meat". "they say it tastes bitter".* This is in line with the observation of (Hiscock *et al.*, 2018), where "tasteless" and "bitter", or "bitter aftertaste" were used to describe boiled amaranth. Palatability has been an important issue crucial to the declining rate of consumption of amaranth in South Africa.

Interestingly, other African cultures largely do not hold this view about amaranth as being bitter or having an after taste. Perhaps this is because eating bitter leaves is an inherent part of the food culture. For example, in Nigeria, one of the most commonly consumed vegetables is *Vernonia amygdalina,* a bitter herb commonly referred to as bitter leaf (Aregheore, 2012). The bitter taste of amaranth is due to alkaloids in the plant (Essack *et al.*, 2017). Since the plant has such high genetic variability, different species/varieties may have different alkaloid content. Thus these varieties or genotypes of amaranth with higher alkaloid contents will be considerably more bitter than others (Hiscock *et al.*, 2018). Therefore, there is a need for an intervention by both the government and the scientific community to select through plant breeding, low alkaloid varieties of amaranth to improve the palatability of the crop.

3.4.4 Amaranth food preparation

The most common meals prepared with amaranth were relish with *phutu* (37%), and relish with stiff pap (22%), and relish with *jege* (16%). Less common meals made with the leaves were samp (4%), rice (4%) and beans (2%) (see Figure 3.12). The basic recipe for preparing relish was amaranth, onions, oil, salt. The amaranth was either boiled with salt and onions or stir-fried with onions and vegetable oil. This amaranth recipe is similar to that reported in the literature; however, many people find it too homogenous and the taste not so pleasant (Voster *et al.*, 2007). The older participants also corroborate this, stating that the young ones often criticize the way amaranth is prepared and say it is tailored only for the older generation with one respondent commenting *"they say older people prefer it because it fits their taste buds".*

With many tastes afforded by modern-day diets and fast food, it is little wonder why amaranth prepared simply with salt and onions may seem bland. To make it more appealing to a younger demographic, there needs to be improvements in the amaranth recipes that align with modern-day palates. But care should be taken for these recipes not to include ingredients that are too expensive for them to purchase.

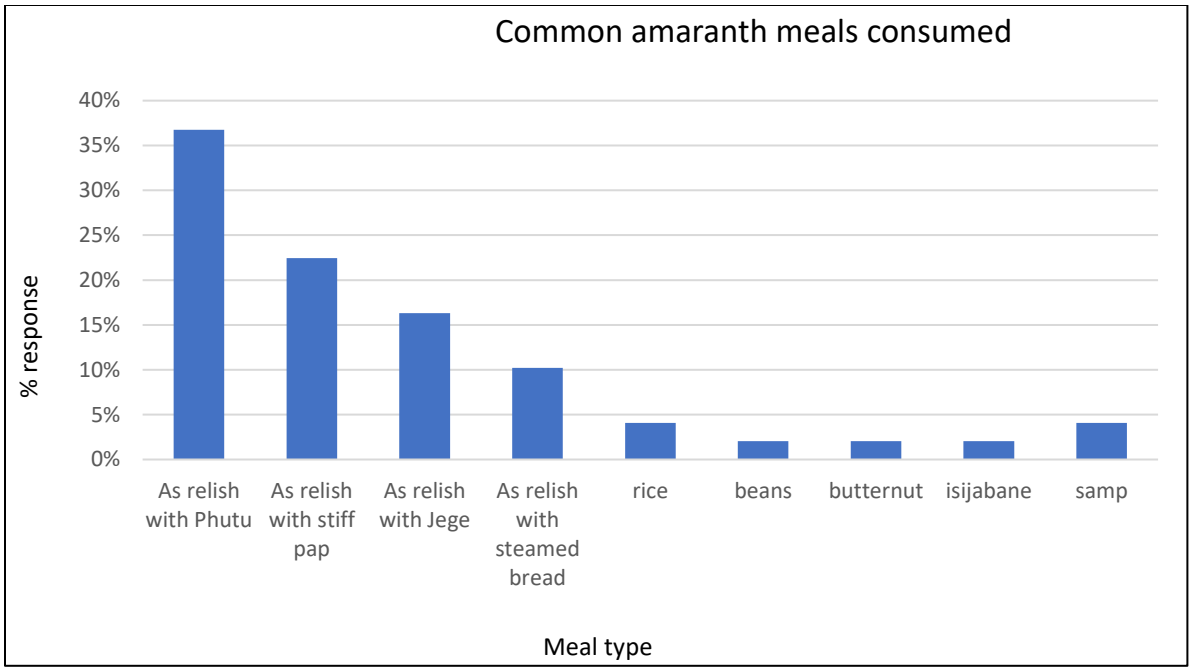

Figure 3.12: Meals eaten alongside amaranth n=100%

3.4.5 Consumption frequency of amaranth

As for the frequency of consumption, participants were asked to indicate how often they consumed amaranth, and this frequency ranged from once in 6 months to every day. Figure 3.13 shows a graphical representation of the consumption frequency of amaranth. A majority of participants (about 74%) reported that they consume amaranth every week, ranging from consuming it daily to just once a week. This shows that there is a high rate of consumption in these communities. However, when asked when last they consumed it, some participants who had earlier indicated they consume amaranth weekly (either every day or more than two days a week) reported 'last month'. At the same time, some said they last consumed amaranth as far back as two months prior to the time of the data collection. As it turns out, participants consumption of amaranth varied from month to month even within the same season, meaning that consumption was higher in some months and lower in others.

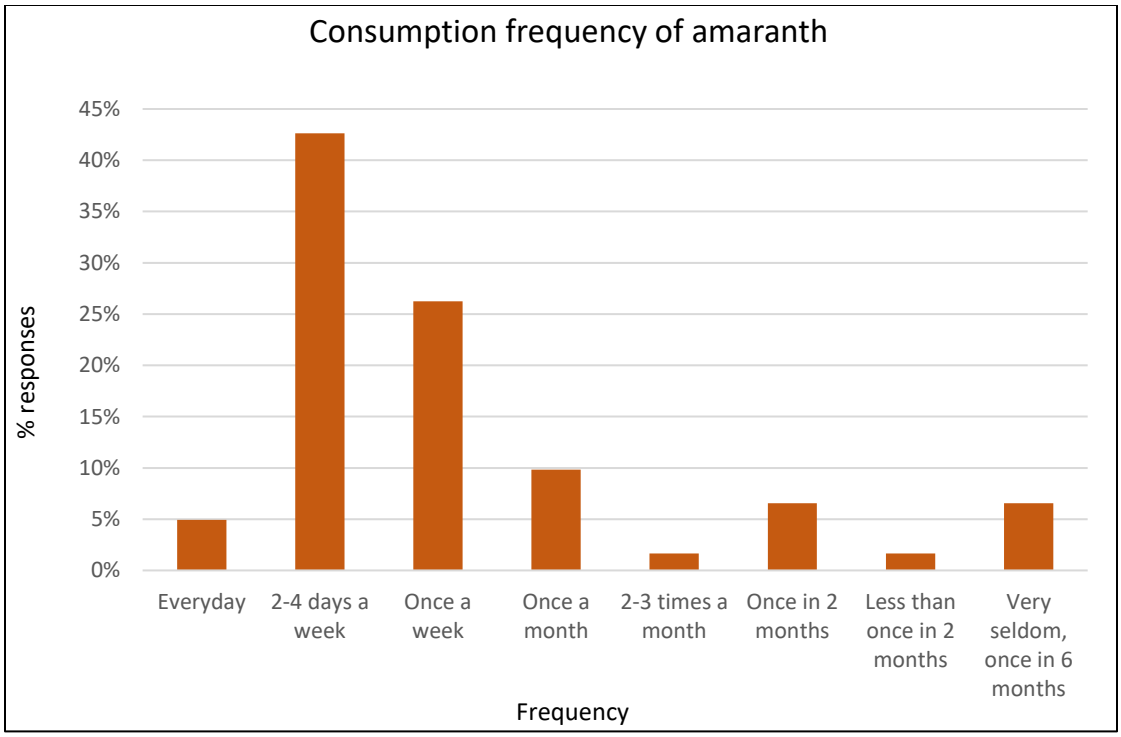

Figure 3.13: Consumption frequency of amaranth n=100%

It has been widely stated that one of the disadvantages of conducting observational studies where participants are expected to document or remember the food they ate previously, is the probability of individuals erroneously reporting details about their food, either by underestimating or overestimating their consumption or even skipping out foods altogether (Chris Kresser, 2018). In this case, participants may generally overestimate or underestimate the frequency with which they consumed amaranth. However, this data still informs us that these communities' participants have significant interaction with amaranth, even though consumption does not remain constant throughout the season.

3.4.6 Source of amaranth

Ninety-eight percent of respondents say they forage amaranth from their own garden, a neighbour's garden or they forage it from the wild. Only 2% reported that they bought amaranth from street vendors. This is in line with several literature reports that most of amaranth consumed is obtained from the wild (Faber *et al.*, 2010; Araya, 2014). While harvesting from the wild is a cheap and easy way to source for amaranth, it may not be sustainable in the long run. The provision and access may be declining as natural habitats come under increasing pressure from development and agriculture expansion (Bharucha & Pretty, 2010). Therefore, to encourage

amaranth to be more mainstream, there must be concerted efforts to encourage individuals to cultivate amaranth rather than harvesting it from the wild.

Another disadvantage of wild foraging of amaranth is that there is no control over the type, variety or species harvested. Due to its high genetic variability, an individual may harvest leaves with higher alkaloid content (which makes the leaves bitter) or higher tannin or phytate content (antinutrient factors) since these traits cannot be identified by merely by looking at the plant. Yet another setback with wild harvesting is that wild foraging may not support the production of amaranth grains. There are no studies or reports that show wild harvesting of amaranth grain. Therefore, by encouraging the cultivation of amaranth, individuals can cultivate varieties which have fewer alkaloids and antinutritional factors and promote the continuous access to and quality of the crop. One way farmers can be encouraged to cultivate amaranth on their farms is through intercropping. Several studies have shown that amaranth successfully intercropped with maize (Awe & Abegunrin, 2009; Sarker *et al.*, 2013; Kumar & Murthy, 2017), legumes (Ng'ang'a *et al.*, 2011; Kumar & Murthy, 2017) and other vegetables (Pitan & Esan, 2014) not only helped to suppress weeds and pests for the main crop but often resulted in higher yields for both crops.

3.4.7 Comparing amaranth to other foods

Respondents were asked to compare amaranth with two of the most common vegetables cabbage and spinach and rank them in terms of nutritional value, availability and affordability. This was done to further capture the respondent's perceived value of amaranth, not in isolation, but in comparison to mainstream vegetables. In terms of nutritional value, 66% of participants ranked amaranth as more nutritious than spinach and cabbage, 10% of respondents said all the vegetables have the same nutritional value. In comparison, 2% said that amaranth's nutritional value is lower than cabbage and spinach. As to why they think amaranth is more nutritious, most respondents seemed to equate the plant's nutritional value to it being an organically grown plant. Participants used words like it is "natural" "organic" to explain why they think amaranth is more nutritious, with responses like *"amaranth is more nutritious because old people eat it a lot and it's natural and organic", "amaranth is not injected with chemicals, so it has more nutritional value", "amaranth has more quality because you harvest it fresh, the nutrition is in the freshness".*

It is not expected that the respondents have scientific knowledge of the actual nutritional content of the crops being compared. However, since the participants demonstrated a consciousness about the nutritional value and the health aspects of their food, it can be expected that proper education on the nutritional benefits of amaranth may generate more interest for and increase

consumption of the plant. According to literature, the belief or perception of nutrition or health aspects of food holds a significant influence on food people's choice (Lappalainen *et al.*, 1998). There were contrasting views about amaranth availability, 48% of respondents say that amaranth was more available than cabbage and spinach and seem to think that amaranth was available all year round. However, 31% say that amaranth is only available during the summer season while cabbage and spinach through irrigation are available year-round. Eight percent of participants thought that spinach was more available than cabbage and amaranth, while 11% thought that cabbage was more available than both spinach and amaranth. It is possible to extend the vegetative stage of amaranth, according to the Department of Agriculture, leaf production can be sustained by the removal of flowers early on (DAFF, 2010). This is not unique to amaranth alone; flower removal in plants can delay senescence and extend a plants' vegetative lifespan since reproductive parts are significant resource sinks that compete with a plant's vegetative functions (Wangolo *et al.*, 2015). Therefore, in that case, amaranth could continuously be available all year round, which is especially beneficial for families who experience food shortages.

In terms of affordability, all the respondents said that amaranth was cheapest because it is free. Some comments *"Amaranth is a gift from God; hence, it is free", "because we don't plant it, we get it for free"*.

Due to the participants' limited knowledge of amaranth grains, no comparison was made between the amaranth seeds (a pseudo-grain) and other grains and cereals like maize or rice.

3.4.8 Farming Amaranth

On the issue of farming amaranth, none of the respondents indicated that they intentionally grow amaranth on their farms, only one respondent reported that she has at one time spread the seeds across her garden but did pay attention or nurture the seedlings or the plant afterwards. In fact, participants did not farm it, but most of them did not see the need to cultivate it and sometimes weed it out from the farms, especially when it begins to mature and flower. The most common reason respondents gave for not farming amaranth was tied to the fact that as a volunteer crop it grows on its own, so naturally, there was no need to cultivate it. Participants gave responses like "*It has never crossed our mind as it grows on its own", "It grows naturally on its own, so why waste time and energy, we just wait for its season and eat as much as we can until the next season", "we never saw the need for growing it, and we know that it grows as a weed, so why would we grow weeds*". Another reason the respondents gave for not farming amaranth was that they do not know how to cultivate it. *"I have no knowledge of how to grow it, it usually just shows up in my*

garden", "there isn't enough information on how to grow it, Agricultural advisors have not come to teach us about farming amaranth", "we don't have much information on how to farm it, e.g., irrigation, best season for it, how much fertilizer it needs etc.".

Following further enquiry on whether they would like to begin cultivating the plant, 54% of respondents say they were willing to farm amaranth, not for personal consumption but to sell in the city, because they think there may be a market for it in the larger cities like Durban and Pietermaritzburg. However, 36% believe there is no market for it and would not like to farm it. Participants in this category seem to think "city dwellers" will not like the taste of amaranth, with such responses as *"there's no market for it", "I don't think the people in the city will like it".* Nine percent, however, responded that they were not sure and would have to see. Of those that show interest in cultivating it, when asked what they will need to start farming it, the primary response was seeds and to a lesser extent, fertilizer. Furthermore, none of the respondents had received any incentive, training, or support for amaranth cultivation.

From the responses above, it is clear that farmers will require adequate training and support (inputs, market access) to start growing amaranth. Even though the Department of Agriculture has materials and manuals on their website on how to cultivate amaranth and other indigenous crops, this information has not been disseminated to the grassroots level and is not available to these farmers. This is mainly because extension service support is lacking in this aspect. As mentioned earlier, none of the participants received any support by extension officers on how to cultivate amaranth even though they had received trainings from extension officers for indigenous crops such as maize and cowpea. Furthermore, creating a market for amaranth is a major milestone that needs to be achieved to encourage the crop's mainstreaming. Consequently, the cultivation of amaranth will contribute to food and nutritional security and provide economic opportunity for the farmers.

If rolled out right, national policies can also be a tool to help promote the farming and consumption of amaranth. Through the draft National Strategy for Indigenous Food Crops, the South African government seeks to promote indigenous foods through research, financial mobilisation and policy interventions. Hence loans and grants can be provided to farmers to cultivate amaranth for local use and export. Sadly, according to a report by the African Centre for Biosafety, budget, and human capital allocation for this intervention has been considerably low (African centre for biosafety, 2014).

3.4.9 Marketing Amaranth

Marketing of amaranth in rural KZN (informal market)

To understand the marketing and current value chain of amaranth within the study sites, shops and retail stores where respondents typically get their food, the local spaza shops and supermarkets (SPAR, Pick n Pay, Shoprite) were surveyed. The survey of the spaza shops showed little evidence for the marketing of amaranth. At the time of the survey, no amaranth (grain and leaves) was being sold in any of the spaza shops visited. The shop keepers confirmed that the common vegetables sold were mostly carrots and cabbage, including some fruits like oranges. Just as in the case of spaza shops, the supermarkets' survey in the various locations also showed no evidence of the sale of amaranth grains or seeds. These stores confirmed that they do not sell amaranth in particular, but do sell other traditional food crops like sweet potatoes, and amadumbe (taro). Furthermore, among the respondents, only one individual confirmed that thay had sold amaranth (which was harvested from the wild) a few times to individuals in urban areas like Pietermaritzburg.

Although several studies have reported on the marketing of indigenous vegetables, none of the studies was specific to amaranth alone. For example, Faber *et al.* (2010) in their study on seven different indigenous vegetables, including amaranth found that only 9% of the respondents bought indigenous vegetables for consumption. Still, the percentage of amaranth bought is not fully determined.

Amaranth in the formal market

To trace amaranth in the broader South African market, a desktop review was carried out to identify producers, marketers, and amaranth processors. The study was able to identify that amaranth grain is being sold at high-end health food stores around the country. These stores typically cater to an urban and wealthier and health conscious demographic. Four (4) online health food stores around the country that sell amaranth grain were reviewed. These are; *Faithful to Nature (https://www.faithful-to-nature.co.za/), Komati Foods (https://komatifoods.co.za/), Wellness Warehouse (https://www.wellnesswarehouse.com/), Founder Foods (https://founderfoods.co.za/).*

The grains at these stores are sold in packages ranging from 400 g to 1 kg weight, and the cost of a kilogram of amaranth grain ranges from 70 – 150 ZAR (see Figure 3.15). In comparison, a kilogram of rice cost between 15 – 25 ZAR and the price for a kilogram of maize meal ranges from 11 – 20 ZAR. Thus at these price levels, amaranth grain may not be affordable to low income

individuals such as the participants of this study. A further discussion with representatives of two stores (Faithful to Nature and Komati Foods) reveal that individuals with specific dietary needs such as who follow a plant based nutrition (vegans and vegetarians), or a gluten free diet make up most of the consumers who purchase amaranth from their stores.

Most of the amaranth grain brands sold in the stores reviewed were imported, mainly from South America; only one brand of amaranth was labelled as South African grown. This shows that there is some level of local production of the locally grown amaranth plant and commercial viability. Since local production is not enough to meet demand, this presents an entryway for small and medium scale farmers to become players in the amaranth market, as long as they produce a quality product on par with imported ones. If the market remains responsive, it may stimulate even more farmers, and other stakeholders like agro-processing merchants, retailers etc., including private investment. This could ultimately lead to increased income and improved livelihoods.

One of the retailers (Faithful to Nature) sold an additional amaranth product, amaranth leaf powder which was priced at 148 ZAR for 150g. This was the only other amaranth product apart from the whole grains being sold in the soteres reviewed. Although this indicates some level of value add for the amaranth leaves, it also shows that there is little to no processing or value add to the amaranth grain as of yet. Also, the review could not identify any establishment involved in the processing of amaranth grain into flour or other by-products. Consequently, Coetzee, (2015) reported that she imported amaranth flour from Kenya to use for her study due to the non-availability of amaranth flour in the country, further proving the limited amount of amaranth and amaranth processing in the country.

Figure 3.14: South African grown amaranth from sold at Faithful to Nature

The fact that amaranth is being sold in these health stores is an indication that more people are becoming aware of it and are consuming it and have easy access to it. However, the downside is that they are sold at prices most rural individuals and food insecure cannot afford, and in locations, they do not have access to. Perhaps a reason why amaranth grain is so expensive is that it is imported and locally produced at such a small scale. This shows that there is an opportunity to increase local production and reduce importation of the crop to regulate further the price such that food-insecure people will be able to afford it.

In addition to local demand, there is also an increasing global demand for amaranth. The global amaranth market share in 2019 was estimated at 5.90 billion USD, and it is expected to expand by 11.8% to reach 15.56 billion USD by 2027 (Reports and Data, 2020). This is because of an increase in the application of amaranth seeds in various industries like personal care and cosmetics, pharmaceutical, and food and beverage (Global Market Insights, 2020). Hence, there is a huge opportunity for South Africa to become a global player in the amaranth market.

3.5 Conclusion

From the study, it can be seen that overall, there is a positive perception of amaranth. While the consumption of amaranth leaves is common but can be improved, knowledge about the grain is lacking, and consumption is barely existent. Due to their higher cost compared to rice and maize, amaranth grains may not be easily affordable to low income individuals such as the respondents for this study. Additionally, access to amaranth grain may be limited as well, since the grains are found at exclusive health stores and not the common retail stores like Shoprite, Pick n Pay, SPAR. Unfortunately, there is an overall reluctance in the cultivating amaranth; this is because the leaves are easily foraged. Yet as important as the leaves are, they cannot be relied on as a major source of calories. Although wild harvesting of amaranth continues to be a source of amaranth leaves, there is no evidence that suggests wild grain harvesting of amaranth is being practised in South Africa.

The grains are a good source of carbohydrates, proteins fibre, and even fatty acids (D'Amico & Schoenlechner, 2017). Therefore, more emphasis should be given to the farming and consumption of grains as much as the leaves, and amaranth should be promoted as a grain like maize, sorghum and millet. However, there is currently little incentive for the farmers to cultivate amaranth grain, in terms of a market for it, inputs, seeds and seedlings and extension support. Therefore, to get people to break out of status-quo and start consciously cultivating the plant, there needs to be a considerable effort from government and other bodies including non-

government organisations, the academic and scientific community, and extension workers. Consequently, the cultivation of amaranth grain will contribute to food and nutritional security and provide economic opportunity for the farmers and introduce a wider variety of producers and entrepreneurs than are currently participating in our food value-chains.

To some degree, the participants are conscious of their health and generally associate the consumption of amaranth with being healthy. Therefore, if they received adequate information about the beneficial nutritive and therapeutic elements of amaranth, they will be even more inclined to consume it. Similarly, since palatability is one of the issues linked to the low consumption of amaranth leaves, the introduction of new recipes can create recipes that are tasty and simple to prepare can also help increase consumption of the plant. In addition to creating new recipes, amaranth can be added to diets without changing the meal, through a simple enrichment or substitution. Since most of the diets consumed by respondents are made from maize, e.g. porridge, *phutu,* maize can be enriched with amaranth grain (partial substitution) or substituted entirely with amaranth grain. This will be an excellent way to increase grain consumption and include high-quality protein in the diets. However, this substitution has to be subject to palatability testing to find the right ratios that will be most acceptable to consumers; this will be discussed further in the next chapter.

References

Adaptation Fund (2014) 'Building Resilience in the Greater uMngeni Catchment', *Project Proposal to the Adaptation Fund*, pp. 1–104. Available at: http://www.adaptation-fund.org/wp-content/uploads/2015/01/SANIE uMngeni Resilience Project_main text+annexes_1 September 2014_final.pdf.

African Centre for Biosafety (2015) 'Agroecology in South Africa: policy and practice. A discussion document', *The African Centre for Biosafety*. Available at: https://www.acbio.org.za/wp-content/uploads/2015/03/Agroecology-SA-report.pdf.

Araya H (2014) 'Indigenous / Traditional African Leafy Vegetables', *Agricultural Reseach Council*. Available at: https://www.arc.agric.za/arc-vopi/Pages/Crop Science/Indigenous-Crops.aspx (Accessed: 14 July 2020).

Aregheore, Eroarome Martin (2012) 'Nutritive Value and Inherent Anti-nutritive Factors in Four Indigenous Edible Leafy Vegetables in Human Nutrition in Nigeria: A Review', *Journal of Food Resource Science*. Science Alert, 1(1), pp. 1–14. doi: 10.3923/jfrs.2012.1.14.

Awe, O. G. & Abegunrin, P. T. (2009) 'Effects of low input tillage and amaranth intercropping system on growth and yield of maize (Zea mays)', *African Journal of Agricultural Research*, 4(7), pp. 578–583.

Bharucha, Zareen & Pretty, Jules (2010) 'The roles and values of wild foods in agricultural systems.', *Philosophical transactions of the Royal Society of London*. The Royal Society, 365(1554), pp. 2913–26. doi: 10.1098/rstb.2010.0123.

Chemining'wa, George, Rudebjer, Per & Hall, Richard (2016) 'Upgrading Grain Amaranth Value Chains in Africa', *Bioversity International*. Kenya, (September), pp. 2014–2016. doi: 10.13140/RG.2.2.27503.43688.

Chris Kresser (2018) 'The Fundamental Problem with Most Nutrition Research', *Kresser Institute*. Available at: https://kresserinstitute.com/the-fundamental-problem-with-most-nutrition-research/ (Accessed: 14 July 2020).

Coetzee, Lizelle (2015) 'Exploring household food security and the acceptance of an amaranth enriched food product', *Masters Thesis, North-West University South Africa*, p. 185. Available at: https://repository.nwu.ac.za/bitstream/handle/10394/19158/Coetzee_L_2015.pdf?sequence=1.

D'Amico, Stefano & Schoenlechner, Regine (2017) 'Amaranth: Its Unique Nutritional and Health-Promoting Attributes', *Gluten-Free Ancient Grains: Cereals, Pseudocereals, and Legumes: Sustainable, Nutritious, and Health-Promoting Foods for the 21st Century*. Elsevier Ltd, pp. 161–178. doi: 10.1016/B978-0-08-100866-9/00006-6.

DAFF (2010) 'Amaranthus: production guideline'. Department of Agriculture, Forestry and Fisheries. Available at: https://www.nda.agric.za/docs/Brochures/Amaranthus.pdf.

Demi, Suleyman Mohammed (2014) 'African indigenous food crops: their roles in combatting chronic diseases in Ghana', *Masters Thesis, Department of Social Justice, Ontario Institute for Studies in Education*. University of Toronto, Ontario, Canada, pp. 1–154. Available at: https://tspace.library.utoronto.ca/bitstream/1807/68528/1/Demi_Suleyman_M_201411_MA_thesis.pdf.

Ekesa, Beatrice Nakhauka (2017) 'Selected Superfoods and Their Derived Superdiets', *Superfood and Functional Food - The Development of Superfoods and Their Roles as Medicine*. InTechOpen, (February), pp. 95–114. doi: 10.5772/67239.

Essack, Humaira, Odhav, Bharti & Mellem, John Jason (2017) 'Screening of traditional South African leafy vegetables for specific anti-nutritional factors before and after processing', *Food Science and Technology*. Sociedade Brasileira de Ciencia e Tecnologia de Alimentos, SBCTA, 37(3), pp. 462–471. doi: 10.1590/1678-457x.20416.

Faber, M., Oelofse, A., Van Jaarsveld, P. J., Wenhold, F. A. M. & Jansen Van Rensburg, W. S. (2010)

'African leafy vegetables consumed by households in the Limpopo and KwaZulu-Natal provinces in South Africa', *South African Journal of Clinical Nutrition*, 23(1), pp. 30–38. doi: 10.1080/16070658.2010.11734255.

FAO, IFAD, UNICEF, WFP, WHO (2019) 'The State Food Security and Nutrition in the World 2019: Safeguarding against economic slowdowns and downturns', *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*. Rome: FAO, p. 239. doi: 10.1109/JSTARS.2014.2300145.

FAO (2013) 'Linkages Between Biodiversity, Food and Nutrition', *Commission on Genetic Resources for Food and Agriculture*. Food and Agricultiral Organisation of the United Nations Rome, Italy. Available at: www.fao.org.

Global Market Insights (2020) 'Amaranth Market Share, Growth | Industry Size Report 2020-2026'. Available at: https://www.gminsights.com/industry-analysis/amaranth-market (Accessed: 5 August 2020).

Gressel, Jonathan (2005) 'Crop Ferality and Volunteerism', *Annals of Botany*. Boca Raton, Florida: CRC Press, p. 422pp.

Van Heerden, Alastair, Barnabas, Ruanne V., Norris, Shane A., Micklesfield, Lisa K., van Rooyen, Heidi & Celum, Connie (2017) 'High prevalence of HIV and non-communicable disease (NCD) risk factors in rural KwaZulu-Natal, South Africa', *Journal of the International AIDS Society*. Wiley Blackwell, 20(2), p. e25012. doi: 10.1002/jia2.25012.

Hiscock, Lucil, Bothma, Carina, Hugo, Arnold, Van Biljon, Angeline & Van Rensburg, Willem Sternberg Jansen (2018) 'Overall liking and sensory profiling of boiled Amaranthus leaves using the check-all-that-apply question', *CYTA - Journal of Food*, 16(1), pp. 822–830. doi: 10.1080/19476337.2018.1464521.

IDF (2020) 'IDF Africa Members', *International Diabetes Federation*. Available at: https://idf.org/our-network/regions-members/africa/members/25-south-africa.html (Accessed: 13 July 2020).

Ineke, Voster, Willem, Jansen van Rensburg, B, Van Zijl J. J. & Venter, Sonja L. (2007) 'The Importance of Traditional Leafy Vegetables in South Africa', *Africa Journal of Food Agriculture Nutrition and Development*, 7(4), pp. 1–13.

Institute of Natural Resources (2004) 'Ethekwini Agricultural Status Quo', *Rural Agricultural Land Potential Assessment and Agribusiness Policy for Ethekwini*. Available at: http://www.durban.gov.za/Documents/City_Government/IDP_Policy/05 Status quo.pdf.

Kansiime, Monica K., Ochieng, Justus, Kessy, Radegunda, Karanja, Daniel, Romney, Dannie & Afari-Sefa, Victor (2018) 'Changing knowledge and perceptions of African indigenous vegetables: the role of community-based nutritional outreach', *Development in Practice* , 28(4), pp. 480–493. doi: 10.1080/09614524.2018.1449814.

Kumar, J. S. Arun & Murthy, N. (2017) 'Intercropping system in grain amaranth for higher productivity and profitability', *Journal of Crop and Weed*, 13(3), pp. 69–72.

Lappalainen, Raimo, Kearney, John & Gibney, Michael (1998) 'A pan EU survey of consumer attitudes to food, nutrition and health: An overview', *Food Quality and Preference*, 9(6), pp. 467–478. doi: 10.1016/s0950-3293(98)00018-4.

Masekoameng, Mosima R. & Molotja, Makwena C. (2019) 'the Role of Indigenous Foods and Indigenous Knowledge Systems for Rural Households' Food Security in Sekhukhune District, Limpopo Province, South Africa', *Ajol.Info*, 4(November), pp. 34–48. Available at: https://www.ajol.info/index.php/jfecs/article/view/191563.

Ng'ang'a, M. N., Ohiokpehai, O., Muasya, R. M. & Omami, E. (2011) 'Intercropping Grain Amaranth (Amaranthus dubius) with Soybean (Glycine max) for Sustainability and Improved Livelihoods in Western Kenya', in *Innovations as Key to the Green Revolution in Africa*. Springer Netherlands, pp. 1203–1210. doi: 10.1007/978-90-481-2543-2_122.

Omamt, E. N., Hammes, P. S. & Robbertse, P. J. (2006) 'Differences in salinity tolerance for growth and water-use efficiency in some amaranth (Amaranthus spp.) genotypes', *New Zealand Journal of Crop and Horticultural Science*, 34(1), pp. 11–22. doi: 10.1080/01140671.2006.9514382.

Oxfam (2014) 'Hidden Hunger in South Africa: The faces of hunger and malnutritionin a food-secure nation'.

Oxfam GB, UK. Available at: www.oxfam.org/grow.

Pauw, Kalie (2005) 'A profile of the Limpopo province: Demographics, poverty, inequality and unemployment', *PROVIDE Project Background paper*, 1(2), pp. 1–20. Available at: http://www.elsenburg.com/provide/documents/BP2005_1_2 Demographics EC.pdf.

Pedersen, Birthe, Kalinowski, L. S. & Eggum, B. O. (1987) 'The nutritive value of amaranth grain (Amaranthus caudatus) - 1. Protein and minerals of raw and processed grain', *Qualitas Plantarum Plant Foods for Human Nutrition*. Martinus Nijhoff/Dr. W. Junk Publishers, 36(4), pp. 309–324. doi: 10.1007/BF01892352.

Pedersen, Birthe, Knudsen, K. E. Bac. & Eggum, B. O. (1990) 'The nutritive value of amaranth grain (Amaranthus caudatus) - 3. Energy and fibre of raw and processed grain', *Plant Foods for Human Nutrition*. Kluwer Academic Publishers, 40(1), pp. 61–71. doi: 10.1007/BF02193780.

Peter, Kavita & Gandhi, Puneet (2017) 'Rediscovering the therapeutic potential of Amaranthus species : A review', *Egyptian Journal of Basic and Applied Sciences*. Mansoura University, 4(3), pp. 196–205. doi: 10.1016/j.ejbas.2017.05.001.

Pitan, O. O. R. & Esan, E. O. (2014) 'Intercropping cucumber with amaranth (Amaranthus cruentus L.) to suppress populations of major insect pests of cucumber (Cucumis sativus L.)', *Archives of Phytopathology and Plant Protection*, 47(9), pp. 1112–1119. doi: 10.1080/03235408.2013.830809.

Rensburg, Jansen van, Averbeke, W. van, Slabbert, R., Faber, M., Jaarsveld, P. van, Heerden, I. van, Wenhold, F. & Oelofse, A. (2007) 'African leafy vegetables in South Africa', *Water South Africa*, 33(3), pp. 317–326.

Reports and Data (2020) *Amaranth Market Size & Share | Trends & Analysis, 2020-2027*. Available at: https://www.reportsanddata.com/report-detail/amaranth-market (Accessed: 27 April 2021).

Sarker, U. K., Dey, S., Kundu, S. & Awal, M. A. (2013) 'On-farm study on intercropping of hybrid maize with short duration vegetables', *J. Bangladesh Agril. Univ*, 11(1), pp. 1–4.

Saubhik, Das (2016) 'Amaranthus: A Promising Crop of Future', *Springer Science*. Singapore, p. 208 pp. doi: DOI 10.1007/978-981-10-1469-7.

Senyolo, Grany M., Wale, Edilegnaw & Ortmann, Gerald F. (2017) 'Analysing the value chain for African leafy vegetables in Limpopo Province, South Africa', *Cogent Arts & Humanities*. doi: 10.1080/23311886.2018.1509417.

Shisana, O., Labadarios, D., Rehle, T., Simbayi, L., Zuma, K., Dhansay, A., Reddy, P., Parker, W., Hoosain, E., Naidoo, P., Hongoro, C., Mchiza, Z., Steyn, NP, Dwane, N., Makoae, M., Maluleke, T., Ramlagan, S., Zungu, N., Evans, MG, Jacobs, L., Faber, M. & SANHANES-1 Team (2013) 'South African National Health and Nutrition Examination Survey (SANHANES-1)'. Cape Town: HSRC Press. doi: 10.1007/s12160-009-9099-2.

Shiundu, Kennedy M. & Oniang'o, Ruth. K. (2007) 'Marketing African Leafy Vegetables: Challenges and Opportunities in the Kenyan Context', *African Journal of Food, Agriculture, Nutrition and Development*, 7(4), pp. 1–17.

Singh, Narpinder & Singh, Prabhjeet (2011) 'Amaranth: Potential Source for Flour Enrichment', *Flour and Breads and their Fortification in Health and Disease Prevention*, pp. 101–111. doi: 10.1016/B978-0-12-380886-8.10010-8.

Taruvinga, Amon & Nengovhela, Rudzani (2015) 'Consumers`Consumers`Perceptions and Consumption Dynamics of African Leafy Vegetables (ALVs): Evidence from Feni Communal Area, Eastern Cape Province, South Africa'. doi: 10.7763/IPCBEE.

Thandeka, N., Sithole, N. & Thamaga-Chitja, J.M Makanda, I. (2011) 'The role of traditional leafy vegetables in household food security in rural KwaZulu-Natal', *Indilinga – African journal of indigenous knowledge systems*, 10(2), pp. 19–5209.

Tzotzos, George T., Head, Graham P. & Hull, Roger (2009) 'Risk Assessment and Management – Environment', in *Genetically Modified Plants*. Elsevier, pp. 88–114. doi: 10.1016/b978-0-12-374106-6.00004-7.

Vorster, HH, Badham, JB & Venter, CS (2013) 'An introduction to the revised food-based dietary guidelines for South Africa', *S Afr J Clin Nutr*, 23(6), pp. 1–164. Available at: www.sajcn.co.za (Accessed: 22 July 2019).

Voster, H. .. Ineke, Willem, Jansen van Rensburg, J.J.B, Van Zijl & Sonja, L. Venter (2007) 'Re-Creating Awareness of Traditional Leafy Vegetables in Communities', *Africa Journal of Food Agriculture Nutrition and Development*, 7(4), pp. 1–3.

Wangolo, Emily, Onyango, Cecilia, Gachene, Charles & Mong'are, Peter (2015) 'Effects of Shoot Tip and Flower Removal on Growth and Yield of Spider Plant (Cleome gynandra L.) in Kenya', *American Journal of Experimental Agriculture*, 8(6), pp. 367–376. doi: 10.9734/ajea/2015/17271.

Weinberger, K. (2007) 'Are indigenous vegetables underutilized crops? Some evidence from Eastern Africa and South East Asia', *Acta Hortic*, 752, pp. 29–34. doi: 10.17660/ActaHortic.2007.752.1.

Chapter 4

4. Sensory Evaluation of Amaranth enriched Porridge

4.1 Introduction

It is widely known that the production and consumption of indigenous foods, amaranth being one of them is on the decline (Rensburg *et al.*, 2007; Thandeka *et al.*, 2011). Some of the reasons mentioned are limited knowledge of the nutritional content (Modi *et al*., 2006), the loss of indigenous knowledge perhaps due to the effects of urbanization, the association of consumption thereof with poverty and low esteem among rural communities (Modi *et al*., 2006) which attaches a certain stigma to traditional crops. This decreased tendency in the utilization and cultivation of amaranth necessitates exploring new ways to improve consumers' perception, thereby increasing its consumption.

As stated in the previous chapter, to encourage people to consume more amaranth, recipes of frequently consumed food products could be enhanced or substituted with amaranth to retain the consumer preferences and enrich their diet and increase its acceptability. It is proposed that if poor households could be educated to cultivate their own grain amaranth, and produce such enriched foods on a commercial level instead of merely being self-sufficient, they could generate income for the community and at the same time increase their dietary diversity (Temple *et al.*, 2011). To accomplish dietary diversity and improved nutritional intake, recipes of frequently consumed food products could be enhanced to improve nutritional intake, if it is deemed acceptable by the consumers (Coetzee, 2015). Moreover, enhancing current traditional recipes may improve households' dietary intake, contributing to a healthier lifestyle and offer a wider variety of food choices. Hence, the ingredients used to enhance the recipes must be of high quality and contribute adequate nourishment to the traditional recipes (Barba de la Rosa *et al*., 2009).
A strategy to use amaranth is to blend it with other cereals in existing products to enhance their nutritional value (Santra & Schoenlechner, 2016). This is referred to as 'food fortification'. A staple food product recipe, such as a bread recipe, or in this instant a porridge recipe can be adapted to be nutritionally improved and standardised to suit consumer acceptance (Payne-Palacio & Theis, 2009). Since most grain-based (rice, maize, wheat) foods lack essential amino acids such as lysine, adjusting the recipe and incorporating nutritionally superior ingredients such as grain amaranth can improve the nutritional quality of these foods (Škrbić & Filipčev, 2008; Mlakar *et al.*, 2009). This could be particularly beneficial for poor communities, especially infants, children, pregnant and lactating mothers (Ayo, 2001). Furthermore, amaranth grain and wheat composite

flour were found suitable for bread manufacturing (Adeyemi *et al*., 1992). Utilization studies have shown amaranth can often be blended at levels up to 75% with other flours without affecting functional properties or taste (Myers, 2001).

Ayo (2001) established that amaranth grain flour could be used up to 15% in the production of amaranth – wheat composite bread without any significant effect on physical and sensory qualities. Hence, the loaves were acceptable to consumers. This is further illustrated by (Sanz-Penella *et al*., 2013) who determined that the inclusion of 20% amaranth flour in bakery products increased the protein content to about 14.96g per 100g, the Zinc (Zn) content by (18.55 mg/100g) and Iron (Fe) by (30.05 mg/100g). Bodroža-Solarov *et al.*, (2008) demonstrated that popped amaranth inclusion of up to 20 % contributed to the increased content of zinc (from 7.21 to 12.59 mg/kg), magnesium (from 137.80 to 396.90 mg/kg), calcium (from 80.79 to 219.04 mg/kg), squalene (from 3.50 to 43.0 mg/100g) and protein (from 12.6 to 13.9 %) (Mlakar *et al.*, 2009).

In their research, Martinez *et al*., (2014) investigated the sensory quality (taste, aroma, flavour, etc.) and technological quality of pasta made from wheat flour and wholemeal amaranth flour at four levels of substitution 15%, 30%, 40% and 50%. They concluded that a maximum substitution level of 30% was suitable to obtain pasta with acceptable technological and sensory quality, with the consequent improvement of nutritional and functional properties given by amaranth flour.
Sanchez-Marroquin *et al.* (1986) evaluated blends of whole amaranth seeds with oats. They found that 40/60 oats/wholemeal amaranth blend possessed characteristics that made it highly suitable for the development of plant-based infant formulas. Furthermore, they observed that oats-amaranth blends either equalled or closely approached values of a commercial soy/oats infant formula in protein content, Protein Efficiency Ratio (PER), and protein digestibility, fat, and fibre content. This could serve as a good substitute for soy in infant feeding, as soy-based infant formulas have been linked to thyroid dysfunction (Fitzpatrick & Mitchell, 2000).

4.1.1 Sensory Acceptability of Amaranth

It is clear from literature that addition of amaranth to a staple grain food product could enhance its nutritional value in terms of increased proteins (Akin Idowu *et al*., 2016) and other macro nutrients like iron, calcium and zinc (Galan *et al.*, 2013). However, it would be pointless to develop a food product if it is not acceptable to the consumer. Since consumers ultimately determine the success of a food product (Moskowitz *et al.*, 2012), consumer food acceptance or sensory evaluation of new products should be conducted to establish if the enhanced food would be enjoyed by consumers and succeed in the market. Sensory characteristics of food such as

appearance, smell, texture, and taste play an important role in consumers' decision to consume a particular food (Messer, 1989; Mccrickerd & Forde, 2016).

A sensory evaluation is a quantitative method to determine consumers' perception, utilising their sensory organs to evaluate sensory attributes of a food product (Civille & Oftedal, 2012). Sensory tests aim to assess sensory attributes such as appearance, flavour and texture, that influence the consumers' preference (Chlopicka *et al.*, 2012) and ascertain which aspects are most liked or disliked by the consumer (Resurreccion, 2008).

There are two types of sensory evaluation procedures, descriptive sensory analyses and consumer-affective tests (Resurreccion 2008). The descriptive sensory analysis uses a highly trained panel to evaluate a food product. In contrast, for consumer-affective testing, the product is evaluated by an untrained panel of regular (would be) users of the food product (Brown & Chambers, 2015). The purpose of the research should ultimately guide a researcher on which sensory procedure to use to measure what is intended to be measured (Civille & Oftedal, 2012), to guide the researcher in developing the best possible food product. However, consumer's food acceptance not only depends on sensory but also on non-sensory factors. The non-sensory factors include price and convenience of preparation, the production methods, consumer attitudes, awareness of health and the environmental, cultural and product beliefs (Jaeger, 2005). The target consumer's needs and motivations should be recognized and considered during the new product or recipe development process. The target consumers should also be part of the sensory panel (Macharia-Mutie *et al.*, 2011).

For this study, consumers' opinions were more important to the researcher than descriptive analysis of attributes regarding the food product. Therefore, the consumer-affective testing was selected for this study, since the opinion of regular users of the food product would determine the evaluated product's acceptance and success. This study's objective was to assess (i) the acceptance of, (ii) the preference for, and (iii) intended consumption of food products made with amaranth grain using untrained consumer sensory panels. For the purpose of this study, amaranth grain a good source of protein and fibre will be used to prepare soft porridge, a stable South African breakfast which is often prepared with maize. The amaranth porridge would then be investigated for acceptability in comparison to the maize porridge.

4.2 Materials and Methods

4.2.1 Study Location

This study was carried out in Swayimane, which is in uMshwathi Local Municipality of the uMgungundlovu District of Kwazulu-Natal, South Africa. This study is the second phase of the main study *"Exploring the potential of mainstreaming amaranth",* and a follow on the previous qualitative study on the knowledge perception and utilization of amaranth in some communities within the uMgungundlovu, eThekwini and uMzinyathi Districts of Kwazulu-Natal (see Chapter 3). This study's focus was to explore ways of promoting the utilization of amaranth within these rural communities that could lead to increased indigenous knowledge and dietary diversity. The study included a sensory evaluation and a focus group discussion held after the sensory evaluation.

4.2.2 Materials and Methods

The amaranth grain used for this research was purchased online from Wellness Warehouse, a health store in South Africa. The rest of the ingredients used for preparing the porridge, i.e. maize meal, sugar and salt were purchased at SPAR in Pietermaritzburg. The amaranth grain was milled using a Kenwood coffee machine; the grains were milled roughly to resemble the maize mealie meal's coarse look.

The amaranth was labelled as South African, which means that it was grown and packaged in South Africa. The study needed to be conducted with amaranth that is of South African origin and not imported. This demonstrates that there is local product availability despite preliminary research indicating that most of the amaranth grain sold in the country (usually found in high end health stores) is imported from South America. Furthermore, De-Beer *et al.* (2016) for their study on the sensory analysis of amaranth enriched bread imported amaranth flour from Kenya for their research.

4.2.3 Pilot Study

A pilot study of the sensory evaluation was conducted before the main study. The pilot study's purpose was to test the recipe and adjust it according to the various samples that are to be prepared and to detect and correct any issues likely to occur during the actual survey. The water content and cooking times were adjusted depending on the amaranth percentage in each sample (see Appendix A). Seven black African female from rural communities within Kwazulu-Natal who are workers from the University of KwaZulu-Natal were recruited as participants for the pilot study.

4.2.4 Preparation of the porridge

Five porridge samples were prepared to consist of varying percentages of amaranth grain and maize meal, from 25%, 50%, 75% and 100% (see Table 4.1 for a breakdown of the ratios). The amaranth grain concentrations used were loosely based on the literature suggestions of Ayo, (2001).

Table 4.1: Breakdown of food samples

Sample	% amaranth	% maize
Sample A	100%	-
Sample B	75%	25%
Sample C	50%	50%
Sample D	25%	75%
Sample E (Control)	-	100%

The porridges were prepared by a black African woman living in a rural area in the Swayimane area of Umgungundlovu District with experience cooking soft porridge (see Figures 4.1 and 4.2). This ensured that the porridges were culturally acceptable to the participants. The porridges were prepared on the morning of the day of data collection in the Food Science Laboratory located at the Dietetics and Human Nutrition and Dietetics Department at the University of KwaZulu-Natal, Pietermaritzburg. After that, the porridges were transported to the research site in air-tight warmers to maintain the temperature. The complete recipe and cooking method of the different porridge samples is outlined in Appendix A.

Figure 4.1: preparation of the porridge by a reisident of Swayimane

Figure 4.2: one of the porridge samples being prepared

4.2.5 Sensory Evaluation

Sensory evaluation was conducted using a panel of 19 untrained panellists selected from volunteers among the Swayimane community members. Care was taken not to include any of the participants from the first phase of the study to reduce bias. All participants were self-reported to have a normal taste and smell sensitivity. Before the study, panellists were briefed about the procedure, and each had to consent to participation verbally. Panellists were requested to refrain from eating or drinking for at least 1 hour before the scheduled time for the tasting. Also, panellists were not given any information as to what they will be testing until after the evaluation had been completed.

The panellists assessed the sensory characteristics of the samples using a sensory evaluation questionnaire. The questionnaire consisted of two sections: demographic questions and a 5-point facial hedonic scale sensory score sheet. The 5-point facial hedonic scale had facial depictions corresponding to each of the following likability scores; 1 = dislike extremely; 2 = dislike slightly; 3 = neutral (neither like or dislike); 4 = like slightly; and 5 = like extremely (see Appendix B sensory questionnaire). The sensory attributes measured were “colour and appearance”, “aroma”, “taste”, “texture” and “overall acceptability”. In addition to the sensory attributes, consumption intent was also measured using a 3 point Likert scale yes/no/maybe. After tasting each sample, the panellists

were asked to mark the facial feature that best described the degree of likability of that sample's various attributes.

The panellists were seated some distance from each other and were asked not to communicate during the sensory evaluation session. This was done to prevent the panellists from influencing each other's responses. Each of the different samples was labelled with random digit numbers (known only to the researcher and the research assistants) and were presented to respondents on trays in random order to be evaluated. Participants were provided with water to rinse their mouths before and in between tasting each porridge sample.

Demographic characteristics of Participants

Participants age ranged from 30 to 70 years old, with a mean age 52±2.4. Most participants had at least a basic primary level education, but none of the panellists had a tertiary level education. Table 4.2 provides a summary of the participants' demographic information.

Table 4.2: Demographic characteristics of Panellist

Characteristic	Number of panellists	percentage
Gender		
Male	5	26%
Female	14	74%
Education level		
Primary education (grades 8-11)	8	42%
Secondary education (grades 8-12	4	21%
Matric (grade 12)	6	32%
Tertiary Education	0	
No formal education	1	5%

4.2.6 Focus group discussion

Fifteen out of the original nineteen panellists participated in the focus group discussion. The focus group discussion was carried out to receive feedback from the panellist. A semi-structured process was adopted for the focus group discussion to ensure consistency in questions asked and allow for flexibility and participation to receive honest feedback from the participants about the sensory evaluation exercise. The focus group discussion was conducted in isiZulu by trained facilitators, and it lasted for about 40 minutes. The session was recorded using a tape recorder. Two major questions were asked during the focus group discussion.

1) Can you describe what you liked and what you did not like about the porridge samples?

2) Now that you have tasted amaranth porridge, will you consider adding it to your diet?

4.2.7 Data Analysis

Sensory data was captured onto Excel spreadsheets and transferred to the R statistical package for analysis. A two-way ANOVA (P≤0.05) was used to determine significant differences in hedonic scores for each sample, after which post-hoc tests (Tukey tests) were carried out to determine the significant differences between the samples examined. For the non-parametric variable "consumption intent" which did not have equal distances between the categories, significant differences in median within the sample groups were determined using the Kruskal-Wallis and the Dunn test used to examine the significant differences between each sample group. The focus groups transcripts were analysed using thematic content analysis (Creswell, 2009). The voice recordings were transcribed and translated from isiZulu to English. The transcript was reviewed to identify major themes and subthemes and organised for final interpretation.

4.3 Results and Discussion

4.3.1 Effect of Amaranth on Sensory Quality

Panellists were required to score each of the porridge samples on the different sensory attributes. Figure 4.3 shows a picture of each of the samples, the darker coloured samples have higher amaranth content compared to the pure maize sample which is white. Mean scores of the sensory attributes sensory evaluation are tabulated in Table 4.3.

Figure 4.3: the different amaranth samples

* sample A 100% amaranth, sample B (75%amaranth) sample C (50% amaranth) sample D (25% amaranth and sample E (100% maize)

Table 4.3: Likability scores of sensory attributes and consumption intent (median) amaranth enriched porridge samples

Mean scores and standard errors for sensory attributes						
Food Sample	**Aroma**	**Colour & Appearance**	**Taste**	**Texture**	**Overall Acceptability**	***Consumption intent**
Sample A (100% amaranth)	4.05±0.18^{a}	4.21±0.18^{ab}	4.32±0.13^{ab}	4.11±0.19^{ab}	4.11±0.15^{a}	1(1,2)^{ab}
Sample B (75:25 amaranth maize blend)	4.05±0.19^{a}	4.11±0.17^{ab}	4.26±0.23^{ab}	4.37±0.19^{a}	4.21±0.18^{a}	1(1,1)^{a}
Sample C (50:50 amaranth maize blend)	4.11±0.19^{a}	4.32±0.15^{a}	4.63±0.11^{a}	3.95±0.14^{ab}	4.05±0.16^{a}	1(1,1)^{ab}
Sample D (25:75 amaranth maize blend	3.58±0.18^{ab}	3.79±0.12^{ab}	4.32±0.11^{ab}	3.74±0.15^{bc}	3.95±0.14^{ab}	1(1,1)^{ab}
Sample E (100% maize)	3.42±0.21^{b}	3.68±0.19^{b}	3.74±0.2^{b}	3.37±0.11^{c}	3.47±0.19^{b}	1(1,3)^{b}
P values	*0.004251*	*0.0080479*	*0.003319*	*2.196e-07*	*0.001885*	*0.0205*

Samples with different superscripts are statistically significant ($p<0.05$). +Hedonic scores: 1 = dislike extremely; 2 = dislike slightly; 3 = neutral (neither like or dislike); 4 = like slightly; and 5 = like extremely. *Consumption intent is reported as median (lower quartile; upper quartile); 1=willing to consume, 2= may consume, 3= not willing to consume. Kruskal-Wallis test and Dunn test was performed because the data was non-parametric.

Colour and Appearance

The overall effect of amaranth fortification on the different porridge samples' colour and appearance was found to be statistically significant ($p < 0.05$). Mean values for colour and appearance varied with the increase in the percentage of amaranth. Samples A, B and C corresponding to 100%, 75% and 50% amaranth content had higher mean scores (≥ 4.0) with the highest mean of 4.3 obtained from sample C which had amaranth to maize ratio of 50:50. Sample D (25% amaranth) and E (100% maize) scored lower means (≤ 4.0) with sample E having the lowest mean score of 3.68. The lower means scored by samples D and E shows that panellists found the colour of these samples less appealing than the samples A, B and C, which had higher amaranth percentages. However, this effect was only statistically significant ($p \leq 0.05$) between sample C and sample E, corresponding to the most acceptable and the least acceptable.

The significant effect of amaranth on the samples' general appearance could be due to the cream-pale colour of the amaranth grain meal, which may look more appealing compared to the pure white colour of the maize meal. However, in their study on amaranth fortified bread in Nigeria, Ayo (2001), arrived at an opposite conclusion where mean scores reduced with an increase in amaranth percentage. This may be because breads prepared with higher amount of amaranth were darker in colour and consequently less attractive to consumers (dos Reis Lemos *et al.*, 2012).

Aroma

The overall effect of amaranth on the porridge samples' aroma was found to be statistically significant ($p < 0.05$). Mean scores for aroma follow a similar pattern as mean scores for colour and appearance. The scores increased from 4.05 both for 100% amaranth (A) and 75% amaranth (B) samples to 4.11 the highest mean score for 50% amaranth sample (C). However, this increase in means from sample A to C was not statistically significant. Consequently, samples D (25% amaranth) and E (100% maize) had lower mean scores (≤ 4.0) with sample E having the lowest score (3.42). The low mean scores for samples D and E demonstrate a decrease in acceptability as amaranth percentage decreases. Post hoc results show that the differences in mean was statistically significant ($p < 0.05$) between sample E and samples A, B and C but not significantly different ($p > 0.05$) to sample D. This clearly shows a distinction in likability for the aroma of the amaranth fortified porridge compared to the pure maize porridge. On the other hand, mean score for sample D was not statistically different from the rest of the samples.

Amaranth grain is said to have an earthy smell due to the presence of intrinsic flavour compounds found in the seeds (Gamel & Linssen, 2008). Exposing the grains to high temperatures such as cooking, baking or popping releases these compounds, producing the distinct smell that may or may not be objectionable to consumers. Food Sense (2011) described amaranth as having a desirable sweet earthy aroma when prepared as a porridge. However, when used in conventional bread recipes, mean scores of aroma decreased consistently with the increase in the bread's amaranth levels (Ayo, 2001; De-Beer *et al.*, 2016). Since the participants in this study were not put off by the amaranth aroma, but even preferred it to the maize porridge, perhaps this could mean that the distinct smell of amaranth is more tolerable when cooked as porridge than when baked into bread and pastries.

Taste

Mean scores recorded for taste were generally higher than those of other parameters. The highest mean score for this parameter (4.6) was recorded for sample C (50%). In comparison, samples A (100% amaranth), B (75% amaranth) and D (25% amaranth) scored slightly lower (4.3, 4.2 and 4.3 respectively) although not statistically different from sample C. The high likability score (≥ 4.0) for this attribute for the amaranth enriched samples can be interpreted as a true reflection of product acceptance by the panellist (Scholtz & Bosman, 2005). As is the trend, sample E, 100% maize porridge had the lowest mean score of (3.74) which was significantly different from sample C (Tukey's HSD $p < 0.05$, 0.018) but not from samples A, B and D.

This study's findings are in line with those of (Akande *et al.*, 2017) where the pure amaranth porridge scored slightly higher means in terms of taste compared pure maize porridge. On the other hand, (Macharia-Mutie *et al.*, 2011) reported that pure amaranth porridge was least preferred than other blends. Other studies have shown that amaranth could substitute for up to 10%–20% of the flour used for traditional breads and cakes without negatively affecting the taste (Ayo, 2001; De-Beer *et al.*, 2016).

Taste is an important parameter to consider in terms of palatability of a food product. Studies have confirmed taste as the single most important determinant of food consumption (Verbeke, 2001). Therefore, factors that can enhance the taste for a food product will increase the likability for the food. Amaranth is said to have an intrinsic nutty taste, which may not be familiar to a majority of consumers. However, since the highest likability score for taste was obtained for the 50:50 amaranth/maize blend this could imply that amaranth taste is best enhanced when combined with other grains.

Texture

The pattern for mean scores for texture differs slightly from that of other attributes. Sample B (75% amaranth) had the highest mean likability score (4.37) than all the other samples. Samples A (100% amaranth) and C (50:50 blend) scored slightly lower (4.11, 3.95 respectively) but not statistically different to sample B. Mean scores continue to decrease for samples D and E, with sample E having the lowest mean score for this attribute.

As is consistent with the findings recorded for other attributes, the likability scores for texture decreased significantly with the percentage amaranth decrease. This effect was significant at the 25% amaranth as well as the 100% maize porridge. Post hoc test revealed that the mean score for sample D differed significantly from sample B. In contrast, sample E differed considerably from all the other samples except sample D. This was similar to the findings of Akande *et al.*, (2017) where means scores for texture was statistically significantly higher for the pure amaranth porridge compared to the maize porridge.

Overall Acceptability

In terms of overall acceptability, samples A, B and C scored higher likability scores (>4.0) which mean they were more acceptable compared to samples D and E (< 4.0). The highest likability rating was scored by sample B (75% amaranth) although this was not statistically different to samples A and C. Mean scores decreased for samples D (25% amaranth) and the control sample E (100% maize), however, this decrease was not statistically significant at 25% added amaranth but was significant for sample E. The high acceptance scores for samples A, B and C can be interpreted as a true reflection of product acceptance by the respondents.

This result for the overall attribute acceptability is consistent with those of other sensory attributes where porridge samples with higher amaranth percentages (samples A, B and C) had significantly higher mean scores compared to samples with low (<50%) amaranth content. A similar study assessing sensory acceptability of amaranth fortified porridge in Kenya, (Macharia-Mutie *et al.*, 2011) concluded that 70:30 amaranth – maize porridge was most preferred as a suitable food to be used in a food-based approach program.

Consumption intent

Participants were asked to score their consumption intent for each of the samples on a scale of 1-3, (1) Yes, will readily consume (2) No, will not consume, and (3) Maybe, will probably consume. Median ratings for samples A and B denote that all (100%) of the participants indicated their

willingness consume amaranth, which dropped to 95% for sample D, 84% for sample A and 79% for sample E. this finding supports previous studies that demonstrate a positive relationship between likability and consumption intent of food.

The following (Figures 4.4 to 4.9), provides a graphical a breakdown of the scores for each sensory attribute

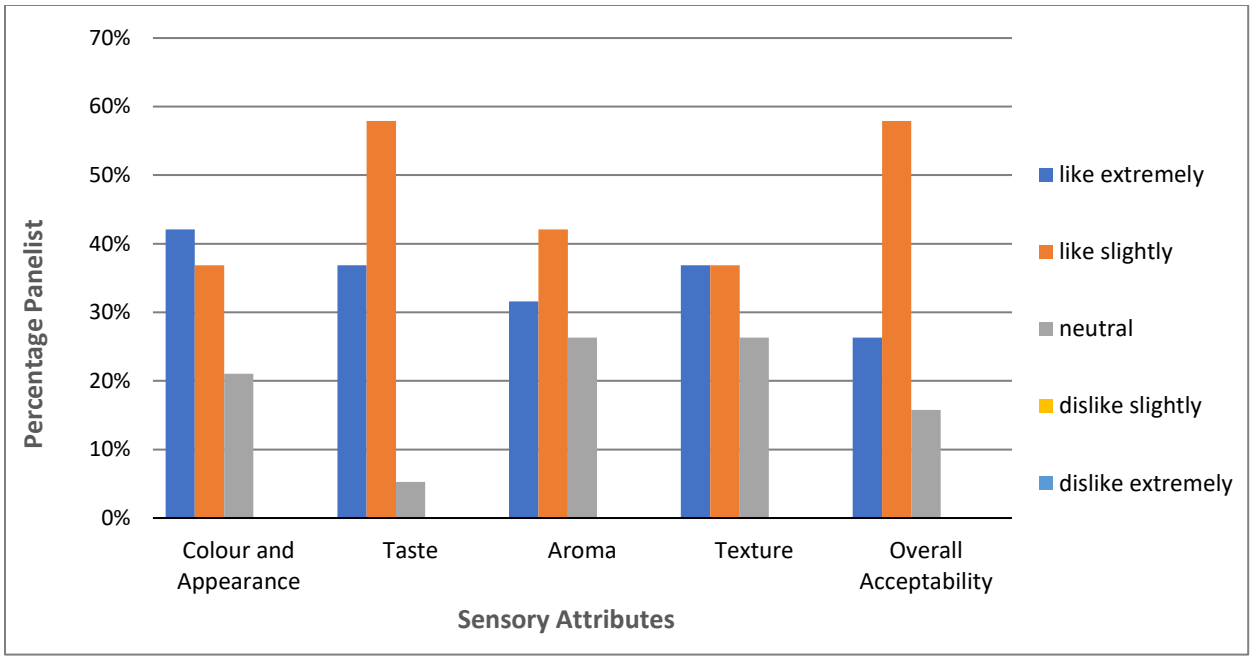

Figure 4.4: Ratings of sensory attributes of Sample A porridge made with 100% amaranth grain meal

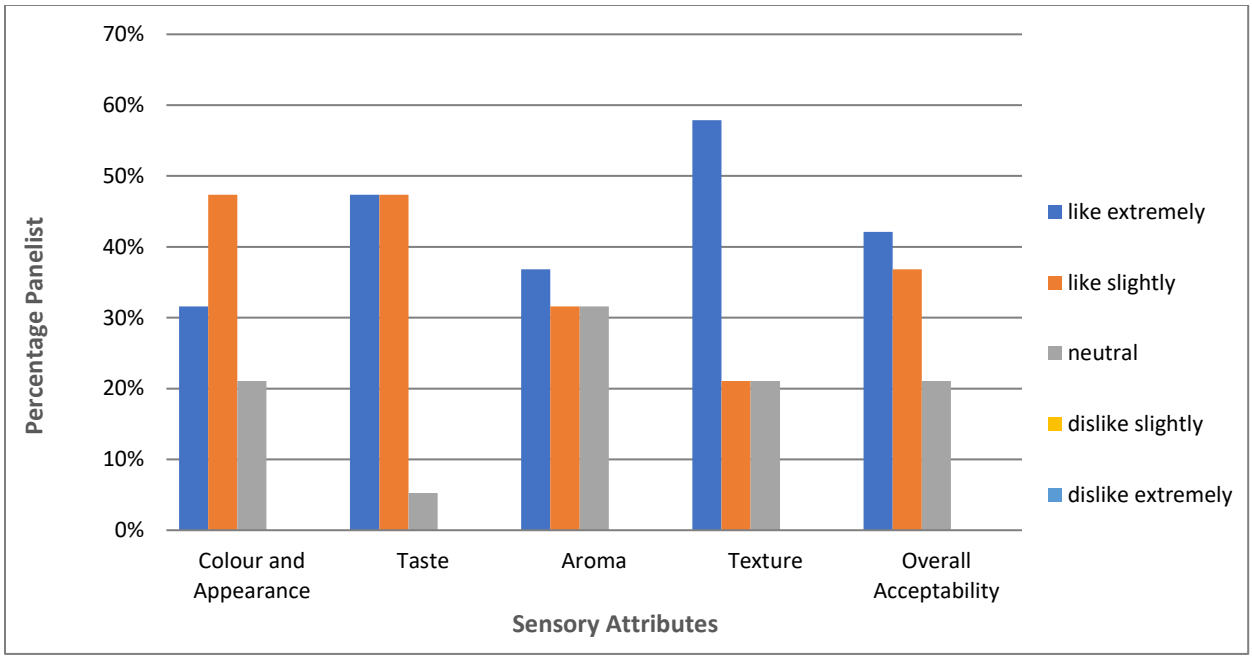

Figure 4.5: Ratings of sensory attributes of Sample B porridge made with 75% amaranth grain meal

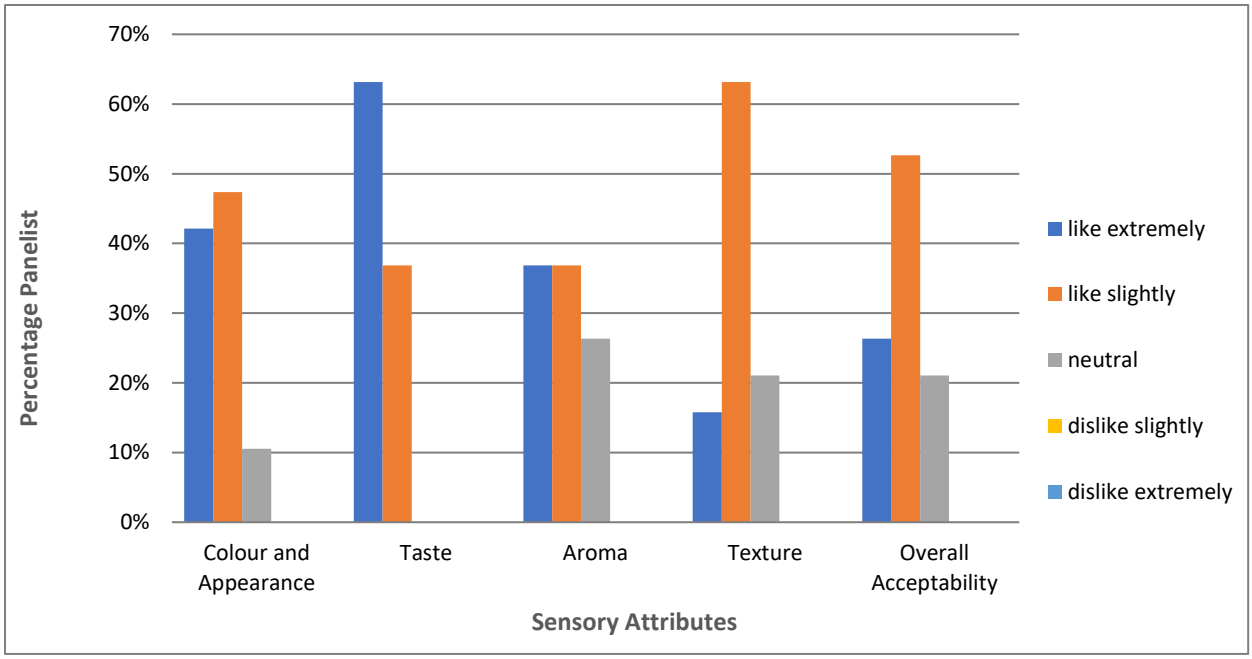

Figure 4.6: Ratings of sensory attributes of Sample C porridge made with 50% amaranth grain meal

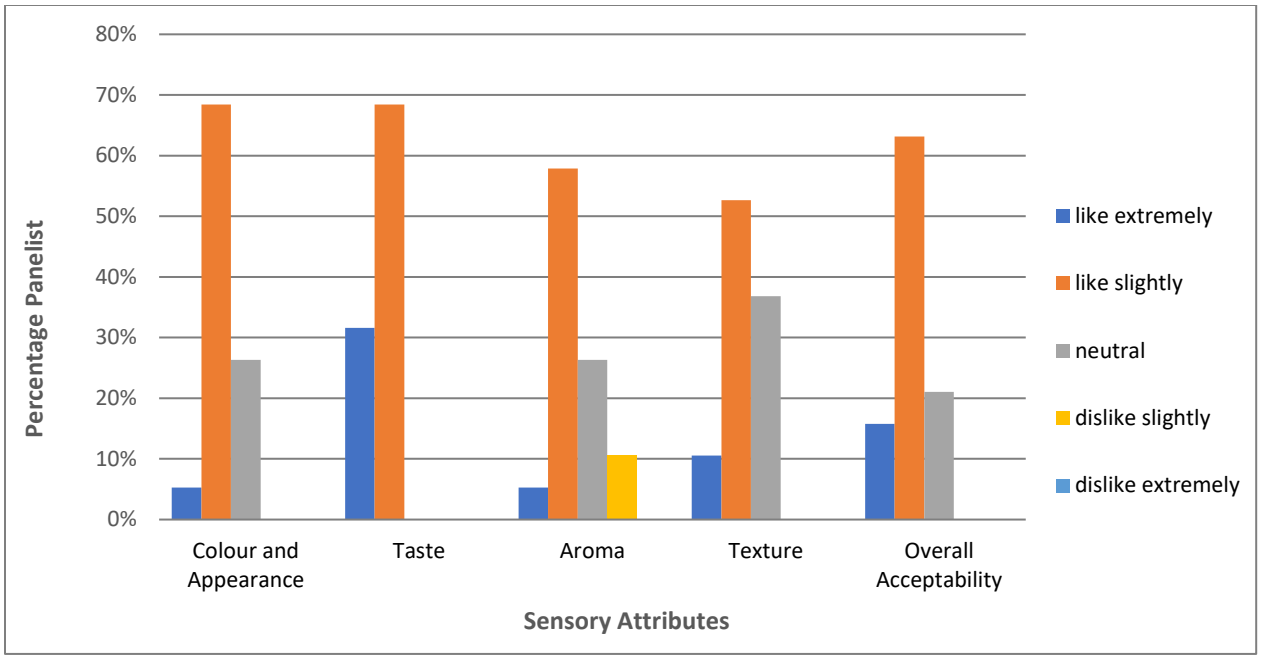

Figure 4.7: Ratings of sensory attributes of Sample C porridge made with 25% amaranth grain meal

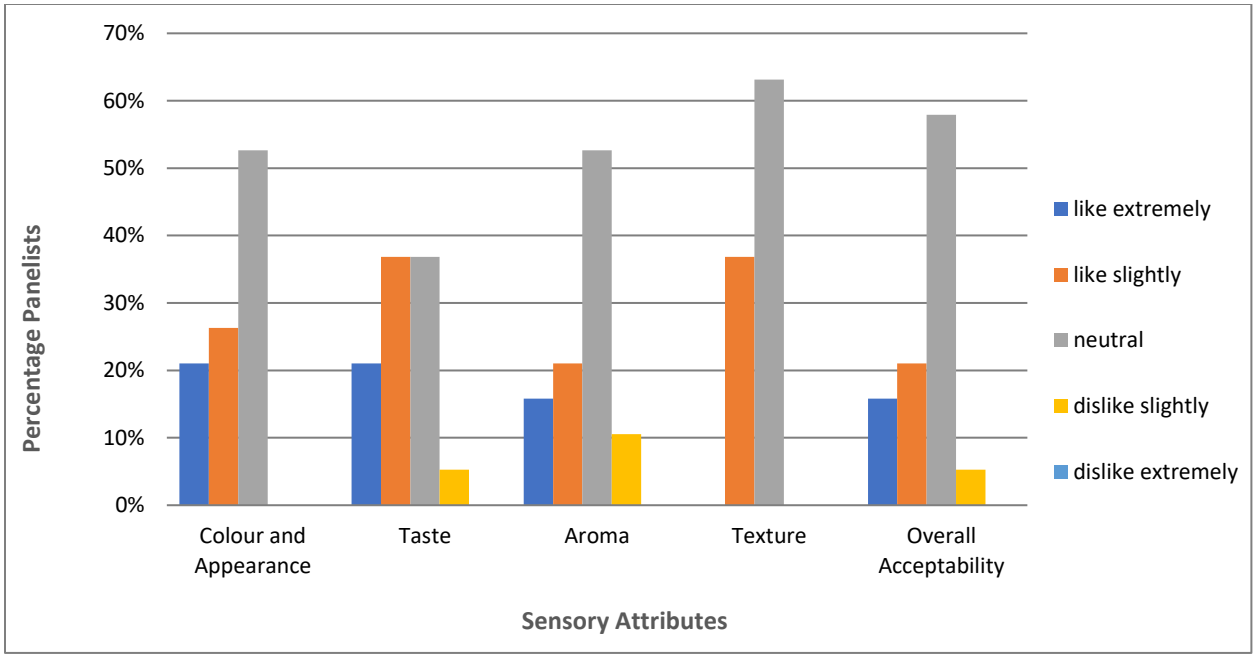

Figure 4.8: Ratings of sensory attributes of Sample E porridge made with 100% maize meal

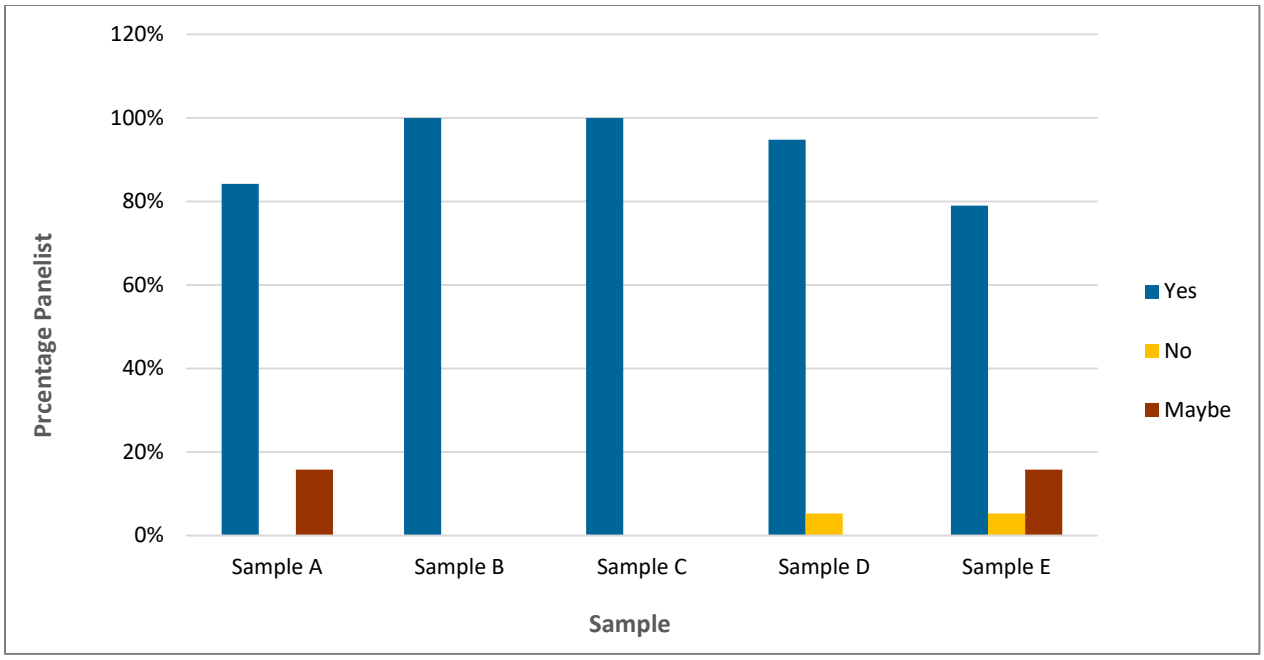

Figure 4.9: Ratings of consumption intent of the different porridge samples

4.3.2 Focus Group Discussion on Sensory Evaluation

At the end of the sensory evaluation, a focus group discussion was held with the participants to further understand the participants' sensory and consumer perceptions regarding the different porridge samples.

Overall perception and acceptability

Overall, the participants showed a positive perception of the sensory characteristics of the enriched amaranth porridge. Participants were asked what they liked and what they did not like about the porridge samples. In terms of what they liked, participants indicated that they preferred the samples' aroma with a more cream-coloured look which were samples A, B and C over the whiter looking samples (D and E). This is consistent with the results of the sensory evaluation. Most participants stated that their least favourite was porridge which was the 100% maize porridge (sample E), the reason they gave for their preference of the enriched amaranth porridge over the pure maize porridge was that it felt refreshing to taste something different, the smell, colour and the taste provided something new for them as they were tired of consuming maize. The participants also stated that they believe amaranth was more nutritious than maize; therefore, consuming the amaranth fortified porridge will provide them with better nutrition and ensure their families' dietary diversity.

The participants showed a lot of enthusiasm for, and a willingness to include amaranth grain in their diet. Nearly a third of the participants indicated they would consume amaranth enriched porridges up to 4 days/week while the rest of the group indicated a daily consumption as long as there is availability. Participants also stated that not only are they willing to consume it, they are also keen to encourage their friends and neighbours to consume the amaranth enriched porridge. This is quite promising, as amaranth grains could potentially serve as a source of affordable food protein, especially in low socio-economic regions. Household consumption can be supported by promoting the advantages of amaranth and/or other foods to enhance nutritional diversity.

Knowledge and availability of amaranth grains

One of the themes that evolved in the course of the discussion was the availability of amaranth grain in the stores, which could hinder the consumption of the grain. Participants mentioned that they would be willing to buy amaranth grain only if it were about the same price range or preferably cheaper than commercial maize meal. When asked if they will be willing to cultivate the amaranth grain themselves, participants had mixed responses. Participants indicated that they do not know how to cultivate it or how to prepare the seeds. One participant reported that the seeds of the amaranth growing in their garden are black and not cream – golden coloured type used for the porridge preparation and wondered if it was viable for consumption.

Amaranth comes in various major colours, cream, golden, brown, red, black (Arêas *et al.*, 2015). There has been no evidence suggesting that any of the amaranth grain colour types are toxic to humans (Stegelmeier *et al.*, 2013). However, the black seeds may indicate the invasive weedy species palmer amaranth (Mohseni-Moghadam *et al.*, 2013). But according to the National Research Council, (2006), black-seeded amaranth variety was used exclusively as a vegetable, while the pale-coloured variety as grain and it has probably been used that way in Africa since the 16th or 17th centuries. This could indicate that the black seeded amaranth may not be visually appealing to consumers thus not ideal for cooking, although further studies have to determine that. Since most of the studies on amaranth grains have used the cream-coloured seeded variety, there is little information on the acceptability of the other colours of the seeds.

4.4 Conclusion

Amaranth porridge was acceptable to consumers at the various concentrations of amaranth. The 50:50 amaranth maize blend (sample C) and the 75:25 amaranth maize blend (sample B) consistently had the highest likability scores for the different sensory attributes. A reduction in likability scores was observed for the 25% of added amaranth (sample D) and for the pure maize

porridge (sample E). However, sample E consistently underperformed throughout the study, having the lowest scores (statistically significant) for all sensory parameters measured.

Participants of the study showed a high consumption intent for the amaranth fortified porridge. This was influenced by the samples' sensory attributes, health beliefs, or even cultural beliefs about amaranth in general. However, this is subject to the availability as well as the price of the amaranth grain. As discussed in the previous chapter, the fact that amaranth grain is unavailable in the traditional supermarkets is a major factor affecting its utilisation. The grain cost can also be a major setback, as amaranth currently retails for 70 ZAR per kg, compared to maize, which is sold at about 10 – 15 ZAR per kg. Furthermore, the lack of proper knowledge on cultivation or how to process and prepare meals from amaranth grain can also hinder the consumption of amaranth.

The various amaranth blends' high protein content could improve the protein quality of food for the participants, especially for infants and children. However, this experiment may need to be conducted with a much younger demographic to ascertain or establish that amaranth can be a palatability source of food for all ages. A positive experience regarding sensory attributes of “new” amaranth products by a younger demographic may result in younger consumers changing their negative beliefs and accepting or even having a preference for amaranth.

References

Adeyemi, I. ., Adabiri, B. ., Afolabi, O. . & Oke, O. . (1992) 'Evaluation of some quality characteristics and baking potential of amaranth flour', *Nigerian Food Journal*, 10, pp. 8–15.

Akande, O. A., Nakimbugwe, D. & Mukisa, I. M. (2017) 'Optimization of extrusion conditions for the production of instant grain amaranth-based porridge flour', *Food Science & Nutrition*. Wiley-Blackwell, 5(6), pp. 1205–1214. doi: 10.1002/fsn3.513.

Akin Idowu, Pamela, E., Odunola, Oyeronke, A., Gbadegesin, Michael, A., Oke, Abiola, Orkpeh & Uterdzua (2016) 'Assessment of the protein quality of twenty nine grain amaranth (Amaranthus spp. L.) accessions using amino acid analysis and one-dimensional electrophoresis', *African Journal of Biotechnology*, 12(15), pp. 1802–1810. doi: 10.5897/ajb12.2971.

Arêas, J. A. G., Carlos-Menezes, A. C. C. C. & Soares, R. A. M. (2015) 'Amaranth', in *Encyclopedia of Food and Health*. Elsevier Inc., pp. 135–140. doi: 10.1016/B978-0-12-384947-2.00025-8.

Ayo, J. A. (2001) 'The effect of amaranth grain flour on the quality of bread', *International Journal of Food Properties*, 4(2), pp. 341–351. doi: 10.1081/JFP-100105198.

Bodroža-Solarov, M., FILIPČEV, B., KEVREŠAN, Ž., MANDIĆ, A. & ŠIMURINA, O. (2008) 'Quality of bread supplemented with popped Amaranthus Cruentus grain', *Journal of Food Process Engineering*. John Wiley & Sons, Ltd (10.1111), 31(5), pp. 602–618. doi: 10.1111/j.1745-4530.2007.00177.x.

Brown, M. D. & Chambers, D. H. (2015) 'Sensory Characteristics and Comparison of Commercial Plain Yogurts and 2 New Production Sample Options', *Journal of food science*. J Food Sci, 80(12), pp. S2957–S2969. doi: 10.1111/1750-3841.13128.

Caselato-Sousa, V. M. & Amaya-Farf´an, J. (2012) 'State of Knowledge on Amaranth Grain: A Comprehensive Review', *Journal of Food Science*, 77(4), pp. 93–104. doi: 10.1111/j.1750-3841.2012.02645.x.

Chlopicka, J., Pasko, P., Gorinstein, S., Jedryas, A. & Zagrodzki, P. (2012) 'Total phenolic and total flavonoid content, antioxidant activity and sensory evaluation of pseudocereal breads', *LWT - Food Science and Technology*, 46, pp. 548–555. doi: 10.1016/j.lwt.2011.11.009.

Civille, G. V. & Oftedal, K. N. (2012) 'Sensory evaluation techniques — Make "good for you" taste "good"', *Physiology & Behavior*. Elsevier, 107(4), pp. 598–605. doi: 10.1016/J.PHYSBEH.2012.04.015.

Coetzee, L. (2015) 'Exploring household food security and the acceptance of an amaranth enriched food product', *Masters Thesis, North-West University South Africa*, p. 185. Available at: https://repository.nwu.ac.za/bitstream/handle/10394/19158/Coetzee_L_2015.pdf?sequence=1.

De-Beer, H., Mielmann, A. & Coetzee, L. (2016) 'Exploring the acceptability of amaranth-enriched bread to support household food security', *British Food Journal*, Vol. 118(Issue: 11), p. pp.2632-2646,. Available at: https://doi.org/10.1108/BFJ-06-2016-0240.

Fitzpatrick, M. & Mitchell, K. (2000) 'Soy formulas and the effects of isoflavones on the thyroid', *New Zealand Medical Journal*, 113(1103), pp. 24–26.

Food Sense (2011) 'Amaranth Grain'. Utah State university. Available at: www.ethicallyessential.coop, (Accessed: 14 November 2020).

Galan, M. G., Drago, S. R., Armada, M. & González José, R. (2013) 'Iron, zinc and calcium dialyzability from extruded product based on whole grain amaranth (Amaranthus caudatus and Amaranthus cruentus) and amaranth/Zea mays blends', *International Journal of Food Sciences and Nutrition*. Int J Food Sci Nutr, 64(4), pp. 502–507. doi: 10.3109/09637486.2012.753038.

Gamel, T. H. & Linssen, J. P. H. (2008) 'FLAVOR COMPOUNDS OF POPPED AMARANTH SEEDS', *Journal of Food Processing and Preservation*. John Wiley & Sons, Ltd, 32(4), pp. 656–668. doi: 10.1111/j.1745-4549.2008.00206.x.

Huerta-Ocampo, J. Á. & Barba de la Rosa, A. P. (2011) 'Amaranth: A Pseudo-Cereal with Nutraceutical Properties', *Current Nutrition & Food Science*, 7(1), pp. 1–9. doi: 10.2174/157340111794941076.

Jaeger, S. R. (2005) 'Non-sensory factors in sensory science research'. doi: 10.1016/j.foodqual.2005.03.004.

Macharia-Mutie, C. W., van de Wiel, A. M., Moreno-Londono, A. M., Mwangi, A. M. & Brouwer, I. D. (2011) 'Sensory acceptability and factors predicting the consumption of grain amaranth in Kenya', *Ecology of Food and Nutrition*, 50(5), pp. 375–392. doi: 10.1080/03670244.2011.604584.

Martinez, C. S., Ribotta, P. D., Añón, M. C. & León, A. E. (2014) 'Effect of amaranth flour (Amaranthus mantegazzianus) on the technological and sensory quality of bread wheat pasta', *Food Science and Technology International*, 20(2), pp. 127–135. doi: 10.1177/1082013213476072.

Mccrickerd, K. & Forde, C. G. (2016) 'Sensory influences on food intake control: Moving beyond palatability', *Obesity Reviews*, 17(1), pp. 18–29. doi: 10.1111/obr.12340.

Messer, E. (1989) 'Methods for determinants of food intake', in Pelto, G. H., Pelto, P. J., and Messer, E. (eds) *Research methods in nutritional anthropology*. Hong Kong: United Nations University Press. Available at: https://archive.unu.edu/unupress/unupbooks/80632e/80632E00.htm (Accessed: 8 December 2020).

Mlakar, S., Turinek, M. & Jakop, M. (2009) 'Nutrition value and use of grain amaranth: potential future application in bread making', *Agricultura*, 6, pp. 43–53. doi: 10.1016/j.learninstruc.2016.07.002.

Modi, M., Modi, A. and & Hendriks, S. (2006) 'Potential role for wild vegetables in household food Security: a preliminary case study in Kwazulu-Natal, South Africa', *African Journal of Food, Agriculture, Nutrition and Development*, 6(1), pp. 1–13.

Mohseni-Moghadam, M., Kent, C. & Ashigh, J. (2013) 'Palmer Amaranth Biology and Management'. New Mexico: New Mexico State University, pp. 1–8. Available at: https://aces.nmsu.edu/pubs/_a/A617/welcome.html.

Moskowitz, H. R., Beckley, J. H. & Resurreccion, A. V. A. (2012) 'Sensory and consumer research in food product design and development'. Blackwell Pub, p. 424. Available at: https://www.wiley.com/en-us/Sensory+and+Consumer+Research+in+Food+Product+Design+and+Development%2C+2nd+Edition-p-9780813813660.

Myers, R. L. (2001) 'A Lost Crop of the Americas How to Grow Grain Amaranth'. Columbia, MO: Jefferson Institute, pp. 4–7.

National Research Council (2006) 'Amaranth', in *Lost Crops of Africa: Volume II: Vegetables*. Washington, DC: The National Academies Press. doi: https://doi.org/10.17226/11763.

Payne-Palacio, J. & Theis, M. (2009) *Introduction to Foodservice*. 11th edn. Columbus, Ohio: Pearson/Prentice Hall.

dos Reis Lemos, A., Dias CAPRILES, V., Elisabeth Machado PINTO SILVA, M. E. & Alfredo Gomes ARÊAS, J. (2012) 'Effect of incorporation of amaranth on the physical properties and nutritional value of cheese bread', *Ciênc. Tecnol. Aliment*, 32(3), pp. 427–431. doi: 10.1590/S0101-20612012005000079.

Rensburg, J. van, Averbeke, W. van, Slabbert, R., Faber, M., Jaarsveld, P. van, Heerden, I. van, Wenhold, F. & Oelofse, A. (2007) 'African leafy vegetables in South Africa', *Water South Africa*, 33(3), pp. 317–326.

Resurreccion, A. V. . (2008) 'Consumer Sensory Testing for Food Product Development', in Aaron L. Brody, J. B. L. (ed.) *Developing New Food Products for a Changing Marketplace*. 2nd editio. Boca Raton, Florida: CRC Press, pp. 365–405. Available at: https://books.google.co.za/books?hl=en&lr=&id=ReLKBQAAQBAJ&oi=fnd&pg=PA365&dq=48+Resurreccion,+A.V.A.+1998.+Consumer+sensory+testing+for+product+development.+Gaithersburg,+MD:+Aspen+Publishers.&ots=ykN2XBUnc7&sig=rwHVCFUxNsTQdT-e9Fvw46y1s_A#v=onepage&q&f=.

Sanchez-Marroquin, A., Valle, F. R. Del, Escobedo, M., Avitia, R., Maya, S. & Vega, M. (1986) 'Evaluation of Whole Amaranth (Amaranthus cruentus) Flour, Its Air-Classified Fractions, and Blends of These with Wheat and Oats as Possible Components for Infant Formulas', *Journal of Food Science*. John Wiley & Sons, Ltd (10.1111), 51(5), pp. 1231–1234. doi: 10.1111/j.1365-2621.1986.tb13092.x.

Santra, D. K. & Schoenlechner, R. (2016) 'Amaranth Part 2-Sustainability, Processing, and Applications of Amaranth', *Sustainable Protein Sources*. Elsevier Inc., pp. 257–264. doi: 10.1016/B978-0-12-802778-

3.00016-0.

Sanz-Penella, J. M., Wronkowska, M., Soral-Smietana, M. & Haros, M. (2013) 'Effect of whole amaranth flour on bread properties and nutritive value', *LWT - Food Science and Technology*, 50(2), pp. 679–685. doi: 10.1016/j.lwt.2012.07.031.

Scholtz, S. C. & Bosman, M. J. C. (2005) 'Consumer acceptance of high-fibre muffins and rusks baked with red palm olein', *International Journal of Food Science and Technology*. John Wiley & Sons, Ltd, 40(8), pp. 857–866. doi: 10.1111/j.1365-2621.2005.01012.x.

Škrbić, B. & Filipčev, B. (2008) 'Nutritional and sensory evaluation of wheat breads supplemented with oleic-rich sunflower seed', *Food Chemistry*, 108(1), pp. 119–129. doi: 10.1016/j.foodchem.2007.10.052.

Stegelmeier, B. L., Field, R., Panter, K. E., Hall, J. O., Welch, K. D., Pfister, J. A., Gardner, D. R., Lee, S. T., Colegate, S., Davis, T. Z., Green, B. T. & Cook, D. (2013) 'Selected Poisonous Plants Affecting Animal and Human Health', in Haschek, W. et al. (eds) *Haschek and Rousseaux's Handbook of Toxicologic Pathology*. Third Edit. Cambridge, Massachusetts: Academy Press, pp. 1259–1314. doi: 10.1016/B978-0-12-415759-0.00040-6.

Temple, N. J., Steyn, N. P., Fourie, J. & De Villiers, A. (2011) 'Price and availability of healthy food: A study in rural South Africa', *Nutrition*. Elsevier, 27(1), pp. 55–58. doi: 10.1016/J.NUT.2009.12.004.

Thandeka, N., Sithole, N. & Thamaga-Chitja, J.M Makanda, I. (2011) 'The role of traditional leafy vegetables in household food security in rural KwaZulu-Natal', *Indilinga – African journal of indigenous knowledge systems*, 10(2), pp. 19–5209.

Verbeke, W. (2001) 'Beliefs, attitude and behaviour towards fresh meat revisited after the Belgian dioxin crisis', *Food Quality and Preference*. Elsevier, 12(8), pp. 489–498. doi: 10.1016/S0950-3293(01)00042-8.

Chapter 5

5. Conclusion and Recommendations

5.1 Conclusion

This study was aimed at exploring the potential of mainstreaming amaranth in South African diets, to contribute to dietary diversity, food and nutrition security as well as the sustainability of our agro-food system. Thus, the study focused on the knowledge and perception, production and access, as well as the consumption of amaranth and how these ultimately affect the use or inclusion of the of the crop in everyday diets. The objectives of the study were to;

1) To understand the knowledge and awareness, perception, consumption patterns of amaranth
2) Explore the market for amaranth and its products, as well as consumer accessibility to the crop
3) Determine the palatability and acceptance of a meal which have been enriched with amaranth.

Several interviews including focus group discussions and desktop reviews were carried out to assess peoples' interaction with amaranth in the target communities. A review of literature was also carried out to study the distinctive characteristics of amaranth as well as the market environment and finally, a sensory evaluation exercise to determine likability and consumption intent of amaranth meal. This chapter presents an overview of the study, as summary of the major findings and draws out recommendations towards factors that promote consumption of the crop. The major findings from the study are summarized below.

5.3.1 Knowledge and Perception

In terms of perception, the study shows that there is a positive perception about amaranth (leaves), not only that, but it is also being held in high regard as *"good",* "*nutritious food"* and even "*the meat from mother nature*" indicating a significant cultural belief about the crop. This also indicate that the negative perception (as poor man's food) about the crop is changing and that people are a lot more accepting of amaranth as a nutritious addition to their diets. In fact, participants during the course of the study demonstrated a willingness and eagerness to explore other ways to achieve optimum nutrition and dietary diversity through the use of amaranth. Participants in the study had some knowledge of amaranth, they could easily describe phenotypic features of the different species/varieties plant like colour, height, inflorescence etc. They

demonstrated knowledge on how to extend the vegetative state of the plant by cutting off the inflorescence so that the leaves do not turn fibrous and inedible. However, some knowledge gaps were identified in the course of the study. Chief among these is the lack of knowledge on how to cultivate amaranth, poor knowledge about the utilization of the grain and a limited variety in the number of recipes for the preparation of the leaves.

5.3.2 Production

In terms of production, the study showed little or no cultivation of amaranth and some participants even expressed hesitation to cultivate it. A majority of the participants have experienced amaranth only as a volunteer crop, that is, it freely grows in farms, gardens or in the wild without being cultivated. Once the seeds are introduced either deliberately or unintentionally (seeds that are carried by the wind, dropped by birds, or are inadvertently mixed into compost), they become established and spread in that area over generations. This prolific nature of the crop comes as a major advantage as it ensures availability of the crop for each season, making it a free and accessible food with no cost or labour requirement. This could be one of the reasons for the reluctance of some participants to explore cultivating amaranth. On the other hand, this prolific characteristic may serve as a disadvantage as some weedy species like palmer amaranth have become a major noxious invasive (albeit innocuous) weed in the country (CropLife SA, 2019).

5.3.3 Consumption, palatability and acceptance

All participants currently consume or have consumed amaranth leaves at some point in their lives, especially while they were younger. There was a high variation in consumption frequency which ranged from every day for some individuals for to a few of times year for others, but none of the respondents consumed the grains. However, sensory evaluation results show that there is a high acceptance of and a willingness to consume porridge made with amaranth grain, even over the traditional porridge made with maize. On the other hand, the desk review did reveal that amaranth grain is being consumed by individuals (presumably less resource poor) who have certain dietary preferences and/ restrictions e.g individuals who are plant based or have gluten intorelance.

5.3.4 Markets and access

The study showed that although amaranth is not available in common retail supermarkets, it can be found in select health stores. These stores are typically niche markets that cater to a health conscious and more affluent demographic. Nevertheless, the presence of amaranth in these stores show that there is a demand for amaranth (at least by that demographic). Therefore, it can

be assumed then that if demand for amaranth and its product increases at grassroot (rural) level, production and supply may increase to meet demand.

5.2 Setbacks to the potential mainstreaming of amaranth

Despite the observations showing the progress on knowledge, production and consumption of amaranth, the study identifies some of the constraints to the inclusion of amaranth in everyday diets. These issues highlighted below are not specific to amaranth alone but affects other ITFCs as well.

1. One of the primary constraints is knowledge, the study identifies several knowledge gaps that limits production and consumption of the crop. Seeing as there has been some level of indigenous knowledge about amaranth, perhaps some of this knowledge on cultivation and utilization of the seeds have been lost over the years. Some of the knowledge gaps identified include lack of knowledge on how to cultivate amaranth, low levels of awareness about the grain and how to cook them, and for the leaves, a lack of variety of recipes and preparation methods.

2. In terms of consumption, participants report consumption of amaranth (leaves) is low for the younger demographic, as they describe the taste of the cooked leaves as bland or bitter. The bitter taste can be attributed to the physiological attributes of the crop, the bland taste could easily be rectified by adopting better recipes. The consumption of the grains is even much lower than the leaves. This is expected, as a majority of participants did not know the seeds were edible or did not know how it is to be prepared and eaten.

3. Closely linked to or a consequence of the poor knowledge of amaranth is the poor rate of production of and the limited access to the crop, especially the grains in South Africa. While the leaves enjoy the convenience of being available (during a season) without the effort of planting it, the grains may not be so easily foraged in large enough quantities that can feed people. This is perhaps why there are no records of wild amaranth grain harvesting.

4. Even though amaranth leaves are free, the fact that it is seasonal means that consumption is limited to only certain months in the year. Poor market access, that is the lack of commercial availability of grains, leaves, seeds and seedlings in the common retail outlets (Shoprite, SPAR) and seed companies highlights a major issue that affects mainstreaming of the crop. For the grains especially, this limited supply means that availability is restricted to certain niche markets like high end health stores, usually too expensive for the low-income families

to afford. Therefore, availability and affordability of the amaranth grain are barriers for the consumption of amaranth grain.

5.3 Recommendations

This study puts forward two major albeit simplified recommendations to increase the use of amaranth and propel it from the realm of obscurity to becoming mainstream. These are: an increase in knowledge and awareness of the crop and secondly to increase amaranth production and access to the crop by consumers. The study identifies that these are key areas that require attention to further support the integration of amaranth into the South African food systems.

5.3.1 Increasing knowledge and awareness for the consumer

The need for exposure and information is crucial in order to extend the knowledge of amaranth. Participants emphasized the need for information that aims to increase awareness on the health and nutritional benefits of amaranth, as well as the skills to prepare it to fit the taste palate of particularly younger consumers that might lead to increased consumption. There are several ways knowledge can be disseminated; by exploiting the medium of already established institutions, like schools, hospitals, media (print, audio and visual) and many more.

a) Promoting amaranth in learning institutions

One way to ensure exposure and education of amaranth is if it is being taught in schools, and this Institutionalisation of amaranth (as well as other ITFCs) could start early with children. Childhood exposure and education could be initiated in school through school curriculum subjects like agriculture, consumer studies. According to the South African National Curriculum Statement on consumer studies, one of the principles of consumer studies includes ‘valuing indigenous knowledge systems’ (Department of Education, 2003). These courses can be targeted to teach children about amaranth and other indigenous foods as well. For example, students should be encouraged to cultivate crops like amaranth in school farms or gardens and can be provided with seedlings and motivated to plant same at home. Consumer courses can teach children the skills on how to cook healthy, and tasty amaranth dishes, and also encourage them to prepare it at home. Additionally, school feeding programmes like the National School Nutrition Programme (NSNP) if implemented effectively, provides an excellent platform for the introduction of amaranth to children. The NSNP pillars include school feeding, nutrition education, and Sustainable Food Production, however, 96% of its budget is spent on school initiatives alone (Devereux *et al.*, 2018). Funding for programmes such as these should not be left to the Government alone, there is need for the private sector to invest necessary resources to achieve all objectives of the programme.

Tertiary institutions of learning like universities and colleges have an even more critical role to play in the promotion of amaranth. Specific modules on ITFCs like amaranth can be introduced to agricultural and agricultural extension courses and courses relating to Dietetics and Nutrition. This will ensure that dieticians, nutritionist, and extension workers are well equipped with knowledge on indigenous foods and can provide targeted guidance on the utilization of these crops. Tertiary institutions also hold a wealth of knowledge through the various research that are continually being carried out. Knowledge and innovation/ research discoveries residing in the databases of universities, colleges and research institutions will be of no use unless it is made available to the public where it informs practice or policy decisions (Elueze, 2016; Giuri *et al.*, 2019). The question then is how to how to bridge that "know-do" gap, that is knowledge existing within learning institutions and the practice or application of that knowledge by the target user group, to yield beneficial outcomes for society. This concept is known as Knowledge Translation (WHO, 2011). This can be carried out through continuing dialogues, interactions, and partnerships within and between different stakeholder groups, within the society i.e groups of knowledge creators, researchers, with policy planners, throughout the agricultural and dietary and health spheres, private for profit and non-profit organisations, producers, manufacturers in the agro-industry and especially the general public.

b) Promoting amaranth in hospitals and health facilities

Information on evidence-based nutrition and health claims of amaranth are needed and should be promoted as such. Health workers such as Community Service Dieticians, Nutrition Coordinators and even Community Health Workers can be an excellent conduit for sharing information about the nutraceutical advantages of amaranth as well as other indigenous foods to promote its consumption. Based on the Integrated Nutrition Programme (INP), health facilities must ensure provision of nutrition interventions including nutrition promotion, education and advocacy (Department of Health, 2001, 2013). Therefore, primary, secondary, and tertiary health care centers all-round the country may have resident clinical nutritionist or dieticians that educates people on dietary diversity, traditional foods (like amaranth) as well as methods of preparations that will ensure food safety, preserve nutrient, increase bioavailability and not uncompromising on the taste. In Swayimane for example, there are clinic days where a mobile clinic team comes to the health centre to provide onsite health assessment and screening services e.g screening for hypertension and diabetes etc, this can be extended to include dieticians/nutritionist who can provide nutrition advice to healthy individuals as well as nutrition therapy to individuals with diet related conditions like diabetes.

A group of individuals who have regular contact with the hospitals are pregnant women and young children. Pregnant women usually have routine prenatal and postnatal check-ups and receive nutrition advice during these hospital visits. This makes it easier to introduce and encourage them to eat nutrient dense amaranth grains and leaves, since it contains a good amount of nutrients like calcium, iron, folate that are essential for the developing foetus (Mcardle *et al.*, 1999; Ladipo, 2000). Young children (especially under 5) also have scheduled hospital visits for things like immunization, growth monitoring etc. For example, through the Integrated Management of Childhood Illnesses (IMCI) protocol which emphasise on immunization and improved nutrition (WHO, 2018), caregivers can be encouraged to feed their growing children amaranth as well as other ITFCs.

5.3.2 Increasing amaranth production and access

Having knowledge on the benefits of amaranth does well to establish a demand for the crop at an individual and even at household level. However, once this demand is established, supply must also rise to meet demand. This means creating an enabling environment and infrastructure to support the increase in production, processing, distribution of amaranth and amaranth products. Increasing production access of amaranth also means increasing farmers knowledge for the cultivation of the crop and providing all necessary support like infrastructure as well as creating an enabling market environment.

It should be made clear to farmers (especially the resource poor farmers) how cultivating amaranth can help them to achieve food self-sufficiency and play a substantial role in sustainable food production to encourage them cultivate the crop. This means that farmers must be taught how to cultivate amaranth and provided with necessary support for it, such as provision of farm inputs such as seeds/seedlings and even financial support. Knowledge about cultivating amaranth is pivotal to further support production and consumption of mainstreaming the crop since harvest and post-harvest processes are crucial for amaranth, especially for the grains. Unlike maize, amaranth grains are tiny and delicate, and requires certain skills and specialized tools for the post-harvest practices like drying, winnowing, cleaning and even storage. This means that extension services whether from the government institutions especially at district or local municipality level, [since local governments is focused on growing local economies and providing infrastructure (South African Government, 2020)] or through private organisations should prioritise indigenous crops like amaranth, not only teach farmers how to cultivate amaranth but also provide the necessary infrastructure to do so.

However, an even greater incentive for cultivating amaranth will be if the farmer can make a profit from the crop. This means having a favourable market environment, attracting more stakeholders including private investors, agro-processing and food manufacturing companies and other agribusinesses etc., to stimulate and maintain domestic markets so that local farmers can easily find market for their amaranth produce. Furthermore, an increase in the number of actors in the amaranth value chain may not only lead to an increase in the amaranth produce but also an increase in the variety of other amaranth products. This could further diversity the market, with the potential for including export opportunities. More value can be added to amaranth through processing and packaging activities. For example, amaranth snacks like popped amaranth, amaranth-chips and amaranth bars (*alegria*) mentioned in chapter 3 which are already popular in the South American region may be introduced to the South African market. Amaranth can also be added to baked goods such as breads, cookies, pies (as part of the crust) or made into pasta. Amaranth tea (either from the leaves or flowers) is also another product that can be introduced to consumers. This has the potential to increase the number amaranth products sold in retail outlets in convenient ways that would attract the attention of consumers. This will not only yield profit for the farmer, aiding in the alleviation of poverty, but it can also help promote rural development and the balance income equality in the country.

While production and availability or access is being assured, access on the part of the consumer not only means physical availability, but being able to afford that commodity. This means that the price must be matched to the consumers' purchasing power. For example, participants mentioned during the sensory evaluation that they will be willing to buy amaranth grains if it is the same price as maize. However, at current prices amaranth is not affordable to them. The interesting thing about amaranth is that it is already being referred to (although with good reason) by such terms as 'superfood'. The Harvard School of Public Health highlighted that the use of terms such as "superfood" or "wholegrain" by the food industry is often times an incentive to inflate prices and boost sales (Nutrition Source, 2020). Hence, there is a possibility that amaranth and any product containing amaranth will be labeled and marketed as such and will continue be priced at an inflated rate. Additionally, if the current global amaranth trend continues, and local markets operates at global market rates trading rates, the high prices of amaranth may hinder local consumption. A good example is the case of quinoa in South America, where due to high prices, local farmers are consuming it less, as they are starting to see quinoa as a product that is too valuable to eat, deciding to take advantage of current prices instead (The Guardian, 2013; David, 2015).

For low-income individuals to be able to afford amaranth and amaranth products, there is the need to reduce the cost of amaranth product to encourage consumption of the crop. There are two ways this can happen; first, either the market gets saturated with amaranth through consistent surplus production which drives prices down based on market forces of supply and demand (Eastin & Arbogast, 2011). Secondly, government provides intervention strategies that could regulate local prices. This could be in the form of subsidies for local producers or implementation of a food price management systems for amaranth products for example, imposing a ceiling on prices below the prevailing market equilibrium prices.

In terms of increasing demand for amaranth among non-resource poor individuals, in addition to creating a variety of tasty high quality amaranth products and by products (as discussed above), it will be beneficial for amaranth to be included in the culinary space. That is, restaurants and even coffee shops in citties can include amaranth in their menus by creating amaranth cuisines that are tasty and appeal to the palate of their consumer base. For example, restaurants can offer gluten free substitutes for recipes that call for Wheat, Barley and Rye such as in deserts, pancakes pies and pasta. This, could inturn increase awareness and demand for amaranth within that demographic amaranth to an wider and more diverse demographic.

5.4 The role of Government Policy

What ultimately ties all these together is having favourable government policies. Therefore, the role of government and policy makers in integrating amaranth into the food system cannot be overemphasised. While the policy environment in South Africa seems progressive in that there are certain policy elements targeting ITFCs enacted to promote sustainable agriculture and address nutrition in a sustainably manner (for example, National Strategy for Indigenous Food Crops, and the Comprehensive Agricultural Support Programme {CASP}), the effectiveness of implementation remains a major setback (African Centre for Biosafety, 2015). Certain forces such as political and corporate allegiances, power plays and populist politics deeply embedded within the socio-political system plays a major role in what policy is enacted and implemented (Delport, 2019). The Government therefore must create an environment in which the traditional foods such as amaranth are safely embedded into the food sector and can thus exploit the comparative and competitive advantages of the sector at regional and international levels. This means not just having the right policy efforts but also strengthening agricultural research, promoting inter-disciplinary approaches and intersectoral collaborations, knowledge translation to inform research priorities and agric-extension services, finance provision, improving the business environment and sustained political leadership as well as governance of the food and agriculture sector.

5.5 Implications for Further Research

This study has demonstrated the richness of amaranth and highlights the potential role it can play promoting food and nutrition security and sustainability of our food system. It identifies certain knowledge gaps that require intervention while at the same time demonstrates the willingness of people to produce and consume the crop. For their full potential to be harnessed, a future research agenda needs to invest much more time and effort on understanding amaranth better, for example, identifying and selecting amaranth species or varieties with less of the chemical compounds that give it its bitter or unpleasant taste, and reduce antinutritional compounds like phytate. Furthermore, research should provide information on amaranth production guidelines specific to South Africa climate and amaranth species found here. Information such as water requirement under irrigation conditions, fertilizer/manure is pertinent to promote cultivation of the crop.

5.6 Final remarks

Overall, this study shows that amaranth (leaves and grains) has the potential to break into mainstream market as nutritious leafy vegetables and a versatile psuedograin with the right recipes and processing techniques. Provided that they are affordable and promoted with information regarding origin, sustainability and nutrition, consumers would be willing to cultivate or purchase and aid their adoption into everyday diets. The cultivation of amaranth in the place of maize would use less water while providing additional protein to people’s diets compared to maize. This shows that amaranth as a traditional food is key for improving the resilience and sustainability of our food system towards achieving food and nutrition security.

References

African Centre for Biosafety (2015) 'Agroecology in South Africa: policy and practice. A discussion document', *The African Centre for Biosafety*. Available at: https://www.acbio.org.za/wp-content/uploads/2015/03/Agroecology-SA-report.pdf.

CropLife SA (2019) 'Palmer Amaranth Action Eradication Plan'. Guateng, South Africa: Herbicide Resistance Action Committee.

David, Diaz (2015) 'Quinoa: Exploring the market dynamics of an Andean staple', *Responsability Investments AG*, pp. 1–18.

Delport, Casey (2019) 'Food and nutrition policy in South Africa policy alignment: The National Vision, Policy Space and Policy Alignment', *Masters Thesis, Department of Agricultural Economics, Faculty of AgriSciences*. Stellenbosch University, (July), p. 96 pp.

Department of Education (2003) 'National Curriculum Statement Grades 10-12 (General) Consumer Studies'. Pretoria: Department of Education, Republic of South Africa, p. 76 pp. Available at: http://education.pwv.gov.za (Accessed: 10 February 2021).

Department of Health (2001) 'Integrated Nutrion Programme: Strategic Plan 2002/3 to 2006/7'. National Directorate: Nutrition and Provincial Nutrition Units. Available at: https://extranet.who.int/nutrition/gina/en/node/23284.

Department of Health (2013) 'Implementation Guidelines for Nutrition Interventions at Health Facilities', *Department of Health, Province of Kwazulu-Natal*. Kwazulu-Natal, South Africa: Nutrition Directorate. Available at: https://www.up.ac.za/media/shared/62/ZP_Files/implementation_guidelines_for_nutrition_interventions_at_health.zp70745.pdf.

Devereux, Stephen, Hochfeld, Tessa, Karriem, Abdulrazak, Mensah, Clement, Morahanye, Matseliso, Msimango, Thabang, Mukubonda, Agnes, Naicker, Sigamoney, Nkomo, Grace, Sanders, David & Sanousi, Mohammed (2018) 'School Feeding in South Africa', *Food Security SA Working Paper Series No 004*. DST-NRF Centre of Excellence in Food Security Pretoria, South Africa. Available at: www.foodsecurity.ac.za.

Eastin, Richard V & Arbogast, Gary L. (2011) 'Demand and Supply Analysis: Introduction'. CFA Institute, p. 153 pp. Available at: https://www.cfainstitute.org/-/media/documents/support/programs/cfa/prerequisite-economics-material-demand-and-supply-analysis-intro.ashx.

Elueze, Isioma (2016) 'Knowledge Translation in Agriculture: A Literature Review / L'application des connaissances dans le secteur agricole: une revue de la littérature', *Canadian Journal of Library and Information Science*, 40(3). Available at: https://ir.lib.uwo.ca/fimspub/93 (Accessed: 10 February 2021).

Giuri, Paola, Munari, Federico, Scandura, Alessandra & Toschi, Laura (2019) 'The strategic orientation of universities in knowledge transfer activities', *Technological Forecasting and Social Change*. Elsevier Inc., 138, pp. 261–278. doi: 10.1016/j.techfore.2018.09.030.

Ladipo, Oladapo A. (2000) 'Nutrition in pregnancy: Mineral and vitamin supplements', in *American Journal of Clinical Nutrition*. American Society for Nutrition, pp. 280S-290S. doi: 10.1093/ajcn/72.1.280s.

Mcardle, Harry J., Ashworth, Cheryl J. & Mcardle, Drhj (1999) 'Micronutrients in fetal growth and development', *British Medical Bulletin*, 55(3), pp. 499–510. Available at: https://academic.oup.com/bmb/article/55/3/499/406082 (Accessed: 9 December 2020).

Nutrition Source (2020) 'Superfoods or Superhype? | The Nutrition Source', *Harvard T.H. Chan School of Public Health*. Available at: https://www.hsph.harvard.edu/nutritionsource/superfoods/ (Accessed: 11 December 2020).

South African Government (2020) 'Local Government'. Available at: https://www.gov.za/about-government/government-system/local-government (Accessed: 11 February 2021).

The Guardian (2013) 'Quinoa: good, evil, or just really complicated?', *Guardian Environment Network*. Available at: https://www.theguardian.com/environment/2013/jan/25/quinoa-good-evil-complicated

(Accessed: 30 November 2020).

WHO (2011) 'Knowledge Translation'. World Health Organization. Available at: https://www.who.int/ageing/projects/knowledge_translation/en/ (Accessed: 10 February 2021).

WHO (2018) 'What is Integrated Management of Childhood Illness (IMCI)'. World Health Organization. Available at: http://www.who.int/maternal_child_adolescent/child/imci/background/en/ (Accessed: 9 December 2020).

Appendix A: AMARANTH PORRIDGE RECIPE

Ingredients

- 8 cups (2000ml) water
- 2 cups (268 g) maize meal
- 2 cups (500 ml) water
- 1 ml salt
- 80 ml sugar

Preparation Method

1. Bring 8 cups (2000 ml) of water to the boil in a heavy duty pot on a defy thermofan stove on high healt (plate control setting 6).
2. Combine the maize meal and 2 cups of water to make a smooth paste.
3. Add the paste to the boiling water and stir until smooth.
4. Drop to medium heat (plate control setting 3) and cook for 25 minutes with the pot lid on and stir occasionally
5. Add 1 ml of salt while cooking.
6. Add 80 ml sugar once the porridge is cooked.

Maize-Amaranth ratios and adjustment to recipe

Percentage Amaranth	Quantity of Amaranth	Quantity of Maize	Adjusted water content	Adjusted cooking times
100%	2 cups	0 cups	Mix with 1.5 cups water	Cook for 40 mins
75%	1.5 cups	0.5 cups	Mix with 1.5 cups water	Cook for 35 mins
50%	1 cup	1 cup	No adjustment made	No adjustment made
25%	1.5 cup	1.5 cups	No adjustment made	No adjustment made

Appendix B: HOUSEHOLD INTERVIEW QUESTIONNAIRE

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saam vorentoe · masiye phambili · forward together

Household Interview Questionnaire

Location: …… **Participants code:** ..……..……

Participant's Name: ……

Date: ……

A. DEMOGRAPHICS

1. **Age:** …….
2. **Gender:** *1=Male*☐ *2=Female*☐
3. **Race:** *1=Black African* ☐ *2=Coloured*☐ *3=White*☐ *4=Indian/Asian*☐
4. **Highest level of education:** *No formal education*☐ *Primary School*☐ *Secondary School (grade 8 to11)*☐ *Matric (grade 12)*☐ *Tertiary*☐
5. **Religion:** *1= Christianity*☐ *2=Traditional*☐ *3= Islam*☐ *4= Other(specify)……*
6. **Number of years spent in the province/district:**

   ……...
7. **What other locations you have lived?**

   ……...
8. **Employment status** *(you can tick more than one) 1= Unemployed*☐ *2= Full-time farmer* ☐ *3= Employed*☐ *4= Pensioner*☐ *5= Other*☐ *(specify)*

   ……..
9. **How many people live in your house?**

1	2	3	4	5	6	7	8	9	>9

10. **What is the total monthly income of the household?**

1= Below R1,500☐ *2= R1,501-R2,500*☐ *3= R2,501-R3,500*☐ *4=R3,501-R4,500*☐ *5=R4,501-R5,500*☐ *6= above R5,500*☐

11. What are the main crops you grow in your garden?

12. Why did you choose to grow these crops?

……

……

……

13. Where do you get your seeds and seedlings from?……

……..

B. FOOD CONSUMPTION

14. What food do you often eat for breakfast? ***(ensure that participant states the complete meal they had e.g porridge and milk or putu and amaas (fermented milk)***

Breakfast	Lunch	Dinner

15. Who is responsible for deciding what type of food is eaten in the household?.....

16. Where are the main places you get your food from? ***Tick appropriately***

Supermarket (Spar, Shoprite, Checkers etc)	

Spaza shop	
Street Vendor	
Others (*Specify)*	

C. AMARANTH CONSUMPTION

17. Do you know Amaranth? *1= Yes*☐ *2=No*☐

18. How long have you known about amaranth?……..

19. What do you know about the amaranth?

……..……

……..……

…….

20. Do you eat Amaranth? *1= Yes*☐ *2=No*☐

21. Why do you eat it?

……..……

…….

……

…….

22. What part of it do you eat? *1= Leaves*☐ *2=Grain*☐

23. Are you aware that it produces grains (seeds) like rice or maize? *1= Yes*☐ *2=No*☐

24. Are you aware that you can cook and eat the grains (seeds)? *1= Yes*☐ *2=No*☐

25. How long have you been eating amaranth?

…….

26. Do you enjoy eating it? *1= Yes*☐ *2=No*☐ *3=Maybe* ☐

27. How do you eat it?

27a List out the meals you prepare with the leaves	27b List out the meals you prepare with the grain

28. Please indicate how often you eat the following vegetables

Tick appropriately		Everyday	Once a week	2-4 days a week	Once a month	2- 3 times a month	Once in 2 months	Less than once in 2 months	Very seldom, once in 6 months
26a	**Spinach**								
26b	**Cabbage**								
26c	**Amaranth**								

29. How will you compare amaranth meals with other commonly consumed vegetables like SPINACH and CABBAGE *(in terms of taste, nutritional quality, price and availability)***?**

Taste	
Nutritional quality	
Price	
Availability	

30. How will you compare amaranth grains (seeds) with commonly consumed grains like MAIZE and RICE *(in terms of taste, nutritional quality, price and availability)***?**

Taste	
Nutritional Quality	
Price	
Availability	

31. Are there members of the household that do not eat amaranth? *1= Yes*☐ *2=No*☐

32. If yes, what do you think can be done to encourage them and others to start eating it?

……

……..……

……

33. Apart from being a source of food, are you aware of other things that amaranth can be used for? (*e.g as cure for diseases, for religious purposes, traditional sacrifice, etc)*

……

……..……

……

34. Are you aware of any potential harm of the plant, if yes, what are those?

……

……

……...

35. Where do you get your amaranth from?

		Tick appropriately
1	I grow it	
2	I get it from a neighbour or a friend who grows it	

3	It grows on its own and I forage from my garden or other gardens or from the wild	
4	I buy it	

36. Why don't you farm amaranth (if participant doesn't grow it)?……..……

……..……

…….

37. Do you think there are benefits to farming it?

……..……

……..……

…….

38. Will you like to farm it? *1= Yes*☐ *2=No*☐

39. If yes, what can be done to help you start growing it?

……..……

……..……

……

40. Have you ever received any support or incentive from the Gov't or any other institution to farm amaranth? *1= Yes*☐ *2= No*☐

41. If yes, what are those?

……

……..…

……

……

Appendix C: SENSORY EVALUATION QUESTIONNIARE

Instructions:

- Please rinse your mouth with water before starting
- Please rinse your mouth with water after tasting each sample
- Please rate the taste, texture, aroma, colour and overall acceptability of the samples by putting a cross on the picture that best describes that sample
- You may re-taste the sample if you wish.

Example:

Aroma	 Very Bad Bad Average Good Very good

SAMPLE NUMBER: **PARTICIPANT NUMBER:**

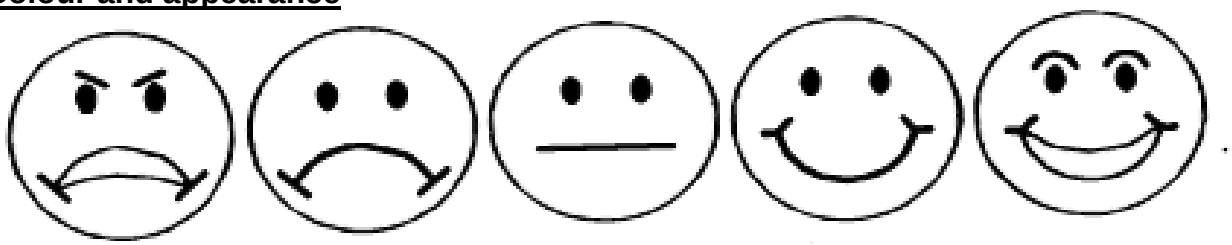
Gender:

Male  *Female* 

Age: _____

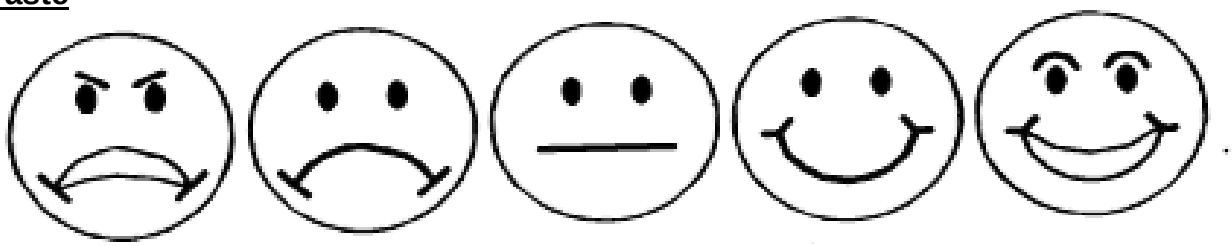
Education Qualification: No formal education ☐ Primary School ☐ Secondary ☐School (grade 8 to11) ☐ Matric (grade 12) ☐ Tertiary ☐

Colour and appearance



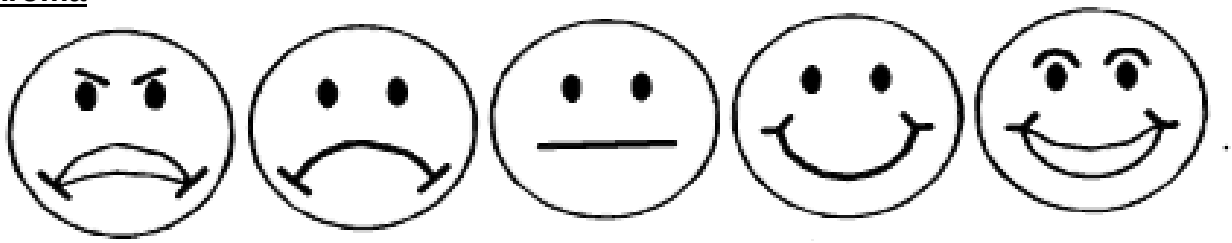
Very Bad Bad Average Good Very Good

Taste



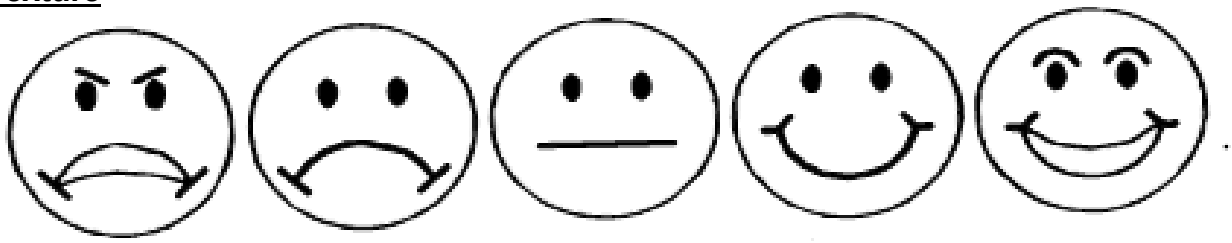
Very Bad Bad Average Good Very Good

Aroma



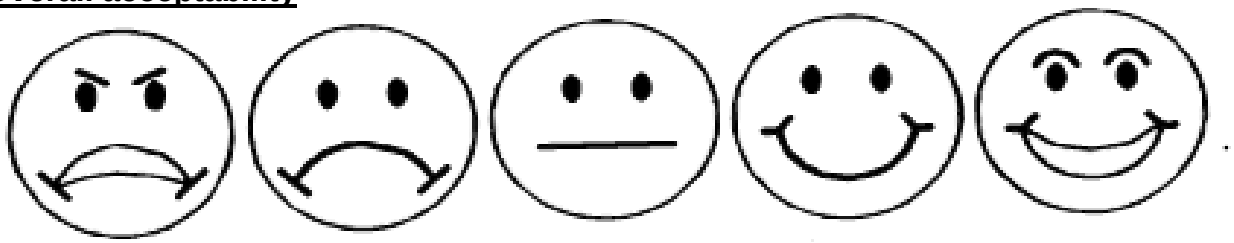
Very Bad Bad Average Good Very Good

Texture



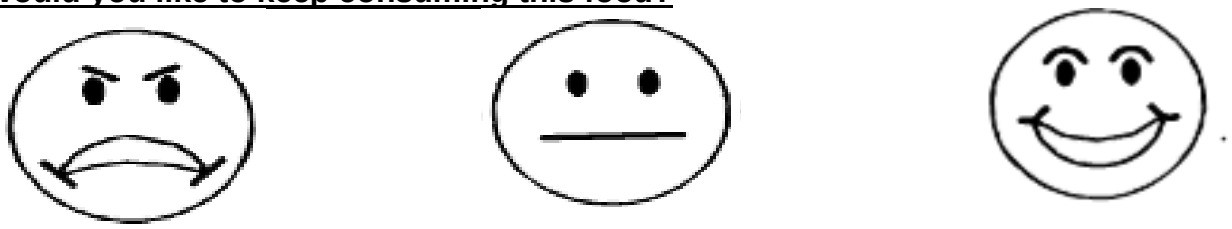
Very Bad Bad Average Good Very Good

Overall acceptability



Very Bad Bad Average Good Very Good

Would you like to keep consuming this food?



No Maybe Yes

Thank you